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REPORT OF I C R P COMMITTEE II ON PERMISSIBLE DOSE FOR INTERNAL RADIATION (1959), WITH BIBLIOGRAPHY FOR BIOLOGICAL, MATHEMATICAL AND PHYSICAL DATA

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*Report of Committee II on Permissible Dose for Internal Radiation (**1959**).*

ERRATA

Page 17 Equation (9): after the "equals" sign, in the expression enclosed in square brackets, a subscript "j" is missing from "λ^r", which should appear as "λ_j^r".

Page 36 Equation (59), the exponential *should read* "$e^{-\lambda r(t-1)}$".
Equation (60), insert "$d\tau$" before the second equals sign. The exponential *should read* "$e^{-\lambda r(u-1)}$".
Equation (61), the exponential *should read* "$e^{-\lambda r(u-1)}$".
Equation (62), the exponential *should read* "$e^{-\lambda r(u-1)}$".

Page 58 The body burden value for $_{51}Sb^{125}$ opposite "Liver", near the foot of the third column, *should read* "3×10^{3}" *not* "3×10^{-3}".

Page 59 Opposite $_{52}Te^{125m}$ (sol.) **Testis**, near the top of the fourth column of the table, "6×10^{-7}" *should read* "6×10^{-3}".

Page 67 Opposite $_{64}Gd^{153}$ (sol.) **GI (LLI)**, about the middle of the fifth column of the table, "10^{-3}" *should read* "10^{-6}".

Page 69 Opposite $_{70}Yb^{175}$ (sol.) **GI (LLI)**, near the top of the fifth column of the table, "**6×10^{-7}**" *should read* "**7×10^{-7}**".

Page 88 In column 4 opposite $C^{14}(CO_2)$, the seventh item down *should read* "0·27" *not* "2·7".

Page 147 Opposite Ileum (68), under the column headed "Cd", "$< 26{\cdot}0$" *should read* "$< 0{\cdot}26$".

Page 175 Opposite Rb^{87} in column 11, just above the bold rule "4×10" *should read* "4×10^{-3}".

Page 176 In the second column of the table, the fourth item down *should read* "Sr^{89}" *not* "S^{89}".

Page 187 In the second column of the table, the fourth item down *should read* "In^{115m}" *not* "in^{115m}".

Page 225 Second item in the second column *should read* "Pa^{233}" *not* "Pa^{232}".

Page 226 Opposite U:
Column 12, "0·33" *should read* "0·11"
Column 13, "$3{\cdot}3 \times 10^{-5}$" *should read* "$1{\cdot}1 \times 10^{-5}$"
Column 14, "0·083" *should read* "0·028".
Opposite U^{230} in column 11, "0·44" *should read* "0·85".

Page 230 Opposite Bk, top item in the ninth column *should read* "10^{-5}".

Page 233 Seventh item from the bottom of the left-hand column *should read* "ε" *not* "ϵ".

HEALTH PHYSICS

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REPORT OF COMMITTEE II ON PERMISSIBLE DOSE FOR INTERNAL RADIATION (1959)

I. INTRODUCTION

THE task of Committee II of the International Commission on Radiological Protection, ICRP, is to recommend values of maximum permissible body burden of radionuclides, q, and maximum permissible concentration of these nuclides, MPC, in air and in water (or food). These values are provided only for the more important radionuclides, and they are applicable primarily to occupational exposure. This Committee has recognized that such compilations are of limited usefulness unless periodically revised to incorporate the best available information and extended to include the values required by new developments and uses. It has worked closely with several of the national committees and in particular with the Internal Dose Committee of the United States National Committee on Radiation Protection, NCRP, in collecting these data and in making revisions of the earlier publications on internal dose published by the NCRP (1953)[1] and by the ICRP (1955).[2] In addition to revising and extending the earlier publications, the members of both committees hope that this publication will be a means of harmonizing and unifying the objectives and principles used by the international committee and by the various national committees in arriving at their decisions. The hope is expressed that the national internal dose committees will apply the same basic principles of radiation protection and will adopt the permissible exposure values recommended by the ICRP or will indicate the conditions and considerations which require their modification.

The basic recommendations concerning radiation exposure have been revised in recent years by the ICRP[3] and are reprinted in the present volume. Similar revisions have been made by the NCRP.[4] An examination of the 1958 Report of the ICRP reveals that the major changes of interest to Committee II are the following:

(1) Instead of a weekly limit, a quarterly limit is recommended thus giving greater flexibility for many operations.

(2) While the permissible quarterly rates are essentially comparable to former permissible rates, a limit on integrated dose is imposed in the case of exposure of the blood-forming organs and the gonads. The ICRP Recommendations[3] also apply the limit on integrated dose to the lenses of the eyes, but the relevant data are so inadequate the eyes are not considered as an organ of reference in this report.

(3) Explicit recommendations are given for some non-occupational groups and limits are suggested for the whole population.

A comparison of the present publication with earlier versions will reveal the very extensive modifications required by new data and methods of estimating internal dose, and will indicate that the number of radionuclides listed in the earlier publications has been increased by about a factor of three. All biological and physical data

used in the earlier versions have been reviewed, and the permissible exposure values have been revised accordingly. Refinements in the calculations for the exposure of the gastrointestinal tract and for chains of radionuclides in the body have resulted in new values for many of the permissible limits. The power function model is discussed in the Appendix as an alternative method of estimating the body burden for certain long-lived radionuclides. The data in the tables are expressed in terms of the exponential or compartment model for retention and elimination, but the maximum permissible concentration (MPC) and body burden values listed in the tables were selected after careful consideration by the Committee of the values obtained by the use of both models. While it is clearly impossible to be completely abreast of the literature in such a rapidly developing field, this revision probably represents the most important findings through 1957 as well as those in a few early publications of 1958.

All MPC values are given for a 40 hr work week as well as for continuous exposure, i.e. a 168 hr week. Previous editions of the internal dose publications gave values based on continuous exposure, partly because these same values sometimes were used, with an appropriate factor, to apply to cases of continuous non-occupational exposure and also because of variations in the actual work week. The values based on a 40 hr work week are included because they are directly applicable to the standard working conditions existing in many countries.

The values listed for continuous occupational exposure are convenient in obtaining permissible levels for special groups and for the population at large in accordance with the Report of the ICRP.[3] The appropriate factors to be applied in obtaining permissible levels for these groups are discussed in Sections II.3 and II.4. Because the continuous exposure values listed neglect several important considerations, particularly differences between children and adults, it should be emphasized that, even when corrected by the above factors, these can only be regarded as interim values for non-occupational exposure. It is hoped that the term "continuous occupational exposure values" will emphasize the provisional nature of their use for other purposes.

Although the data on which the MPC values are based are very incomplete and in some cases uncertain, they embody the latest and best research of hundreds of scientists, and it is believed that these MPC values are the best now available. They should serve as a guide to indicate whether the operational procedures used in practice are adequate to insure that the dose delivered by internally deposited radioactive material does not exceed the pertinent permissible limit set by ICRP.

For many radionuclides the radiation exposure period may last for many months or even a lifetime, although the intake may have occurred in a relatively short time. When radioactive contaminants are deposited in the body, it is often difficult to make an accurate estimate of the total body burden or of its distribution in the body. In most cases, even when the fact is established that a person carries a large internal burden of a radionuclide, little can be done to hasten its elimination from the body. According to one theory, any dose of ionizing radiation, no matter how small, may produce some genetic or somatic damage, and thus, it is considered wise to avoid all unnecessary exposure to radionuclides. This has been pointed out, also, by several national[5] and international[6] organizations. However, in the light of present

knowledge, occupational exposure for the working life of an individual at the maximum permissible values recommended in this report is not expected to entail appreciable risk of damage to the individual or to present a hazard more severe than those commonly accepted in other present day industries. The values given in this report are listed for occupational exposure and must be corrected by the application of appropriate factors for other uses, and in all cases the resultant tissue doses are intended to be in addition to those produced by the natural background and medical exposure.

II. BASIC STANDARDS OF MAXIMUM PERMISSIBLE INTERNAL EXPOSURE

1. Exposure categories. The ICRP[3] has made basic recommendations or suggestions concerning exposure to ionizing radiation for the following categories of exposure:

A. Occupational exposure.

B. Exposure of special groups:

(a) Adults who work in the vicinity of controlled areas (see paragraphs 71 and 72 of the ICRP Report,[3]) but who are not themselves employed on work causing exposure to radiation.

(b) Adults who enter controlled areas occasionally in the course of their duties, but are not regarded as radiation workers.

(c) Members of the public living in the neighborhood of controlled areas.

C. Exposure of the population at large.

In principle both the exposure of individuals and averages over the whole population have to be considered, but recommendations with regard to individual exposure are given only for the groups (A) and (B). Moreover, the ICRP considers that doses resulting from natural background radiation or individual doses resulting from medical and dental exposure are in addition to maximum permissible doses recommended in the report.

2. Occupational exposure (category (A). See paragraphs 46–52, *ICRP Report.*[3]) The basic rules concerned with occupational exposure due to internally deposited radionuclides are the following:

(a) The dose to the gonads or to the total body during any period of 13 consecutive weeks shall not exceed 3 rems. The dose to the gonads or to the total body at age N years shall not exceed $5(N-18)$ rems in case occupational exposure begins after age 18. If occupational exposure begins before age 18, the yearly dose before age 18 shall not exceed 5 rems and the dose to age 30 shall not exceed 60 rems.

(b) The effective RBE dose delivered to the bone from internal or external radiation during any 13 week period averaged over the entire skeleton shall not exceed the average RBE dose to the skeleton due to a body burden of 0.1 μc of Ra^{226}. This is considered to correspond to a dose rate of 0.56 rem/week in the case of Ra^{226} (derived from a dose rate of 0.06 rad/week, an RBE of 10 and $n = 1$). In computing the effective RBE dose to the skeleton, all absorbed energy shall be weighted by a relative damage factor, n. The relative damage factor, n, is taken as one for all energy absorbed from external radiation and for all internal emitters when the element taken into the body is an isotope of radium. If the isotope taken into the body is not an isotope of radium, the relative damage factor, n, is taken as 1 for all energy absorbed from X- or γ-radiation and as 5 for all other energy components,

whether they originate from the parent or the daughters it produces in the body. The effective energy is listed in Table 5 as $\Sigma EF(\text{RBE})n$. For a more detailed discussion and examples, see Section IV.2 and V.1.

(c) The dose to any single organ of the body, excepting the gonads, bone, skin and thyroid, shall not exceed 4 rems in any 13 week period, or 15 rems in 1 year. The dose to skin and thyroid shall not exceed 8 rems in any 13 week period, or 30 rems in 1 year.

The decision of the ICRP[7] (1956) to set the average external occupational exposure at 5 rems/year (corresponding to 0.1 rem/week) is not applied to internal dose calculations except in the cases of radionuclides that are distributed rather uniformly throughout the body or are concentrated in the gonads. The purpose of limiting the average weekly total body dose (0.1 rem) to one-third of the former maximum weekly dose (0.3 rem) was to lessen the possible incidence of certain types of somatic damage, e.g. radiation induced leukemia and shortening of life span, which are considered to result primarily from total body exposure. Obviously, the reduction in the gonad dose was intended to lower the incidence of deleterious genetic mutations that will give rise to effects appearing in future generations.

Inasmuch as the restriction of integrated dose applies primarily to the total body and gonad dose, there is no basic change in the permissible RBE dose rate when individual organs[8] such as liver, spleen, bone, gastrointestinal (GI) tract and kidney are the critical body organs for reasons given in ICRP report paragraph 14.[3] It should be noted that the limits recommended here are maximal. In practice, the average occupationally exposed individual would receive a much lower dose.

Because the direct estimation of the body burden or of the dose to an organ or to the total body is generally difficult, and because in most cases measures to decrease the body burden are rather ineffective and difficult to apply, the only practical procedure for general protection of occupational workers is to limit the concentration of the various radionuclides in the water, food or air available for consumption. It is recommended, therefore, that:

(1) If there is no occupational external exposure, the concentration of a radionuclide or a mixture of radionuclides in air and in water which might be consumed by plant personnel during a 40 hr week be kept at levels not exceeding the appropriate MPC values given in this report. If there is occupational external exposure, the MPC values must be lowered to bring the total RBE doses within the limits prescribed by the basic rules. Thus, if D rem is the quarterly dose permitted to an organ by the basic rules and if external radiation delivers a dose E rem per quarter, then the MPC based on this organ must be reduced by the factor $(D-E)/D$. The calculation of an acceptable level for the case of a mixture of radionuclides is discussed in Section IV.8.

(2) Alternatively, over a period of 13 weeks, the concentrations of the various radionuclides present in air or in water may be allowed to vary, provided the total intake during any 13 week period does not exceed the total intake permitted by exposure at the constant levels indicated in subsection (1) above. It should be realized that while this method is in accordance with the basic recommendations its use is cumbersome, expensive and generally difficult, because it requires accurate and continuous monitoring of work areas and the keeping of detailed exposure histories for each individual. Its use is, therefore, only justified in exceptional cases.

The safest and simplest procedure to use in keeping within the basic limits (a), (b) and (c) in Section II.2 is to keep the level of contamination of the air, water or food consumed by plant personnel in the controlled area at or below the level indicated by the MPC values. These values are given for an exposure period of 40 hr/week and 168 hr/week. If a person's work assignments are such that he spends only 8 hr each week in the exposure area, the applicable MPC values are five times those listed for a 40 hr week in Table 1. However, this requires considerable care to determine that he is effectively unexposed during the remainder of his working week. If he spends 48 hr each week in the exposure area, the applicable MPC values are five-sixths of those listed for a 40 hr work week in Table 1. Similarly, when applied to food they generally will require modification to take account of the amount ingested. This is further discussed in Section IV.9.

Although the formula $5(N - 18)$ permits an average yearly dose to the total body and gonads of only 5 rems, the rules of the ICRP permit up to 3 rems during any interval (e.g. 1 min, 1 day, 1 week, etc.) provided that not more than 3 rems are received in any 13 consecutive weeks. Thus, an older person may receive up to 12 rems in a single year provided his dose does not exceed the limits prescribed by the formula $5(N - 18)$. Although flexibility is also allowed in principle for internal exposures, in practice it is risky and usually impractical to increase the MPC values much beyond those determined for operation over an extended period. The permissible levels do, however, take into account the exposure period (e.g. if the occupational exposures last for only 1 hr/week, the MPC values for a 40 hr week may be increased by a factor of 40), but if there are concurrent external exposures, the MPC must be reduced so that the total dose to any organ does not exceed the maximum permissible limits. In specific individual cases where sufficient monitoring is available (i.e. external monitoring meters, body fluid analyses, air surveys, etc.) and where no exposure has been received for the prior 13 week period, and if the restriction implied by the formula $5(N - 18)$ is not exceeded, a person may work for 1 hr where the concentration in air of an isotope with the total body as the critical organ is $40 \times 13 \times 12/5 = 1200 \times$ the $(\text{MPC})_a$ values for the 40 hr week, but in such a case no further exposure shall be permitted in 13 weeks. This practice should be discouraged because of delays and inaccuracies in methods of estimating the body burden and dose to the organ from such an internally deposited radioactive material. However, if such exposures to contaminated air are unavoidable, the dose often may be reduced materially if appropriate and properly fitting masks are worn.

3. Exposure of special groups (category (B). See paragraphs 53–57, *ICRP Report.*[3]) The dose to the gonads or blood-forming organs of an individual belonging to either of the groups B(a) or B(b) shall not exceed 1.5 rems/year, and the corresponding limit for an individual of class B(c) is set at 0.5 rem/year. If no external radiation results due to operations within the controlled area, the corresponding MPC values for groups B(a) and B(b) are three-tenths of the occupational values for the 40 hr week, and for group B(c) are one-tenth of the occupational values for continuous exposure, i.e. for the 168 hr week. If external radiation results from operations within the controlled area and the dose due to this external radiation is E rems/year, then these values are to be reduced by the factor $(D–E)/D$ where $D = 1.5$ for groups B(a) and

B(b) and $D = 0.5$ for group B(c). The computation of the MPC for a mixture is discussed in Section IV.8.

If the radiation field (external and internal), does not irradiate significantly the gonads or the blood-forming organs, the MPC for an individual belonging to group B(c) shall be one-tenth the MPC value for continuous occupational exposure. Since the exposure of an individual belonging to group B(a) or group B(b) is directly related to his work in or near the controlled area, the MPC for such an individual shall be one-tenth the MPC for occupational exposure of an individual with the same work period per week. Thus, if the working period is 40 hr/week then the MPC for individuals of group B(a) and B(b) shall be one-tenth the MPC for the 40 hr week.

4. Exposure of populations (category (C). See paragraphs 58–68, *ICRP Report.*[3])

(a) Genetic and total body dose. The ICRP in its recent report[3] suggested limits on the *average* genetic dose to a population. These suggested limits are not considered as definitive but are offered for guidance in planning nuclear energy programs. Tentatively, allowing 2 rems to age 30 years for average genetic dose from man-made radiation (exclusive of medical exposures), 1.5 rems is suggested as a limit for internal dose and 0.5 rem as the limit for external dose to the gonads from such sources. Since the continuous occupational levels (168 hr/week) permit 5 rems/year $\times$ 30 years $=$ 150 rems in 30 years to the gonads, such a continuous occupational MPC must be multiplied by a factor of 0.01 to give an equivalent constant level of exposure. The ICRP has suggested that the same dose limit (1.5 rems/30 years) and reduction factor (0.01) are to be applied when the total body is the critical organ. Except in a few cases, sufficient data for an estimate of gonad dose are lacking. In the absence of an MPC value based on the gonads, it is recommended that 0.01 of the MPC based on total body be used. The extent to which many of these nuclides contribute to the gonad dose is under investigation by the Committee.

(b) Somatic dose. For a radionuclide or mixture of radionuclides which does not have the total body or the gonads as critical organ, it is suggested that the average permissible level for large populations be one-thirtieth the continuous occupational value (168 hr/week) computed according to the basic rules (b) and (c) given in Section II.2 above. The Internal Dose Committee of ICRP and of several national organizations are studying the problem of the long-term effects of low-level exposure to the population at large with respect to somatic damage to the exposed individual, genetic damage to his children, ecological damage, etc.

III. MAXIMUM PERMISSIBLE VALUES FOR OCCUPATIONAL EXPOSURE

1. Assumptions and restrictions applying to maximum permissible exposure values in Table 1. The values of q and MPC for an individual will depend upon many factors such as his age, physical condition, eating habits and hygienic standards. They will depend also upon the physical and chemical properties of the radioactive material and the method of intake—by ingestion, by inhalation, through wounds or by absorption through the skin. The paucity of data concerning the effect of most of these factors does not warrant detailed treatment. To keep the required work and the size of this revision within manageable limits, and yet to meet the major needs of scientific and industrial users of isotopes, it has been necessary to limit severely the number

of factors considered. Therefore, MPC values are listed only for relatively insoluble and for the more common soluble compounds, and these compounds are specified only by the extent of solubility rather than by specific chemical structure. The only methods of intake considered are ingestion and inhalation except in a few cases—where submersion presents the greatest hazard criterion. All calculations are based on a "standard man" and thus do not provide for individual variations. The standard man is specified in Tables 6 through 11 and is a somewhat modified version of the standard man defined at the Chalk River Conference[9] (September 1949). This standard man is designed to represent a typical or average adult who is exposed occupationally.

Ideally, maximum permissible body burden, q, and maximum permissible concentration, MPC, should be based on studies of humans who have been exposed to and who have consumed a particular radionuclide under working conditions and over an extended period of time approximating those which are typical of the average occupational exposure. However, human data are very scarce and only in the case of radium does one have an accumulation of human experience for as long as 50 years, which is the minimum for selecting values for chronic exposure to man. Studies using total and partial body counters have been made recently to determine the uptake, distribution, and elimination of trace quantities of some radionuclides in the human body. In a few cases, certain radionuclides have been administered to humans therapeutically, and in some cases, accidents have occurred in which radionuclides have been taken into the body. The data from these cases of human exposure have been studied carefully and, where possible, such data are substituted in this report for earlier data based on animal experiments. For the majority of radionuclides, human data are lacking, and in such cases data from animal experiments must be extrapolated to man. Sometimes even animal data are not available and estimates are made from comparison with elements having similar chemical behavior. Recent studies of trace and minor stable element distribution in the human body[10] have been particularly helpful in these revisions. It is assumed that the normal stable element distribution in the various body organs is typical of the distribution that would result from chronic human exposure to radionuclides of these same elements and that the chemical form is similar. Likewise, a study of the metabolic balance between the trace and minor elements in the food, water, urine and feces of man has yielded direct evidence for the MPC of radionuclides of these elements. Because of the many assumptions and approximations made in applying much of the data in this publication, it is concluded that detailed refinements in the calculations generally are unwarranted.

In Table 1 are the recommended values of maximum permissible total body burden, q, and maximum permissible concentration in air, $(\mathrm{MPC})_a$, and in water, $(\mathrm{MPC})_w$, for about 240 radionuclides. The daily intake of water used in calculating $(\mathrm{MPC})_w$ includes the water content of food, and thus, consideration of the intake of a radionuclide in food is necessary only in case it concentrates in the food during processing or enters the food from other sources. In such cases the $(\mathrm{MPC})_w$ values of Table 1 converted to microcuries per gram are applicable when corrected for daily intake, i.e. to take account of the total intake of radionuclides in the complete diet. This publication includes values for all the radionuclides listed in the previous

publications of NCRP[1] (1953) and of ICRP[2] (1955) together with others for which a need has arisen and for which the necessary biological data are available. With few exceptions (e.g. certain daughter radionuclides and isomeric states), radionuclides with radioactive half-lives shorter than 1 hr are not considered in Table 1. The following are the principal assumptions and conditions which are the bases of the calculations.

(a) In all cases the values are listed both for soluble and for insoluble compounds (an exception is the case of some of the inert gases for which values are given only for the submersion of a person in the inert gas). The lowest values of $(MPC)_a$ and $(MPC)_w$ obtained are in bold-face type both for the soluble and insoluble forms of the isotope. The organs on which these values are based are termed the critical organs and are printed in bold-face type in Table 1.

(b) In all cases the values are computed for occupational exposure at the rate of 40 hr/week, 50 weeks/year for a continuous work period of 50 years, as well as for 50 years of continuous exposure, i.e. 168 hr/week.

(c) In all cases the calculated dose rate which determines the MPC takes into account the actual amounts of the radionuclide in the body or critical organ rather than an assumed state of equilibrium. The MPC values based on a critical organ are set by the requirement that the dose rate (rems/week) after 50 years of occupational exposure shall not exceed the values specified in (a), (b) and (c) of Section II.2. During a 50 year exposure period, equilibrium is reached for the vast majority of the radionuclides because the effective half-life is short compared to this work period (i.e. the term $e^{-0.693t/T}$ in equations (7) and (8) is approximately zero for $t = 50 \times 365$ days). Exceptions to this rule are listed in Table 2. Column 5 of Table 2 gives the effective half-life, and column 6 gives the percentage of equilibrium the body burden attains over a period of occupational exposure lasting 50 years. Most of these exceptions are in the $5f$ type rare earth group of elements which are assigned a biological half-life of 200 years. The extreme case is represented by ten of these radionuclides which reach only 16 per cent of equilibrium in the body in 50 years of occupational exposure.

(d) In the case of a radionuclide which decays to form radioactive daughters, the calculation assumes that only the parent radionuclide enters the body, but the estimated dose rate includes all the energy released by the daughter elements formed in the body. There are two exceptional cases, Rn^{220} and Rn^{222}, where a state of equilibrium typical of that attained in ordinary air is assumed. These cases are discussed further below. In all other cases, it is assumed that only the parent element enters the body. Because the various daughter elements generally have different effective half-lives, the percentage of equilibrium attained is generally not the same for all elements of a chain. Also, the effective energies, i.e. the weighted energy absorbed per disintegration, are not the same for different members of the chain, so that the dose rate after 50 years exposure will generally not be the same percentage of the dose rate resulting from an equilibrium body burden as the figure shown in Table 2. Thus, for radionuclides which decay to form radioactive daughters these percentages give only a rough indication of the percentage of equilibrium dose rate attained at the end of 50 years.

(e) The assumptions and formulas are presented in terms of a compartment

model, i.e. each organ is assigned a biological half-life, and the radionuclide that accumulates in the organ is considered to be eliminated at a constant rate. In general, this is a drastic oversimplification of the situation since the organ retention usually requires several exponentials, or perhaps a power function, for its mathematical representation. Unfortunately, the biological information available generally does not yield detailed information on organ retention, particularly for the conditions and periods of exposure of interest here. In selecting MPC and body burden values, the Committee has considered both multiple exponential and power function models for retention when such information is available, and the values finally selected are in some cases chosen between those calculated by these models. In view of the large measure of uncertainty in many of these cases, and in the interest of uniformity and economy of presentation the biological data in the Tables are given in terms of a single compartment model for each organ considered, with a biological half-life for each. The values of these are selected to produce in 50 years of constant level exposure the retention indicated by the more detailed model, and thus may not represent accurately the situation for short-term exposure. A discussion of the power function model and a table of the necessary parameters for its use are given in the Appendix.

(f) If occupational exposure continues beyond 50 years, the dose rate will continue to rise in the case of the radionuclides listed in Table 2 because they are not in a state of equilibrium under the assumed conditions, but for the radionuclides not listed in Table 2 the maximum permissible dose rate would not be exceeded. However, since the period of occupational exposure probably will not greatly exceed 50 years, and since the maximum permissible body burden, q, would be reached only after 50 years of occupational exposure at the MPC values given in Table 1, the average dose rate over the working life of the individual will be well below the maximum permissible dose rate, even for the isotopes in Table 2. While noteworthy, this observation does not alter the fact that the terminal dose rates would be in violation of the criteria adopted in (a), (b) and (c) of Section II.2, although the integrated dose undoubtedly would be considerably less than that permitted for many radionuclides not listed in Table 2. In the previous publications,[1, 2] the calculations were based on a 70-year exposure. Although this change to an exposure period of 50 years has had very little effect on the MPC values (i.e. a maximum increase of 27 per cent in the MPC values for some of the radionuclides in Table 2), it is believed that this change should be made in the calculations because, for most workers in atomic installations, the working period extends from age 18 to age 65 or less.

(g) The average breathing rate is 10^7 cm^3 per 8 hr work day; this is one-half the air breathed in 24 hr.

(h) The average rate of water consumption is 1100 cm^3 per 8 hr work day; this is one-half the water consumed in 24 hr.

(i) The dose from inert gases with radiation of sufficient energy to penetrate the minimal epidermal layer (7 mg/cm^2) results from external exposure to the surrounding cloud of radioactive gas rather than from the amount of gas in the body.

(j) In general, chemical toxicity is not considered in estimating the body burden or MPC values. However, in the case of uranium, the chemical toxicity has been considered and is the limiting criterion for the longer-lived nuclides of uranium.

2. Units of ionizing radiation used in Table 1. In Table 1 the units are the microcurie (μc) and microcurie per cubic centimeter (μc/cm^3) for maximum permissible quantities of the various radionuclides in the total body, q, and for the maximum permissible concentrations, $(\text{MPC})_a$ and $(\text{MPC})_w$, in air and in water, respectively. One curie is a quantity of a radioactive nuclide in which the number of disintegrations per second is 3.700×10^{10}; the microcurie then, is one-millionth of this amount. In accordance with long established usage, however, the curie of natural uranium is considered to correspond to 3.7×10^{10} dis./sec from U^{238}, 3.7×10^{10} dis./sec from U^{234}, and 1.7×10^{8} dis./sec from U^{235}. Also, the curie of natural thorium is considered to correspond to 3.7×10^{10} dis./sec from Th^{232} and 3.7×10^{10} dis./sec from Th^{228}. The rem is the unit of RBE dose of ionizing radiation in tissue. When a dose is expressed in rems it is superfluous to call it RBE dose. Therefore the unqualified term "dose" alone is used in such cases. The rem corresponds to the dose in tissue which results in biological damage equivalent to that produced per rad of X-radiation (of about 200 kV) having a linear energy transfer, LET, to water of 3.5 keV/μ, i.e., rem = RBE $\times$ rad. The rad corresponds to an energy absorption of ionizing radiation of 100 ergs/g in any medium. In this case the energy absorption is in tissue. The relative biological effectiveness, RBE, in this report is taken as one for β-, γ- and X-radiation, and conversion electrons (for low energy β-emitters, i.e. $E_m \leqslant 0.03$ MeV, the RBE = 1.7), 10 for α-particles, and 20 for recoil atoms. The reader is referred to the Handbook by the International Commission on Radiological Units for detailed information on units.[11]

3. Critical body organ. The values of body burden, q, in column 3 of Table 1 are based on that amount of the radionuclide which is deposited in the total body and produces the maximum permissible RBE dose rate to the body organ listed in column 2. The concentration values in water (columns 4 and 6) and in air (columns 5 and 7) are in turn based on the intake by the standard man who accumulates this body burden as a consequence of occupational exposure for a period of 50 years. In most cases, significantly different values of body burden result when effects on different organs are considered. The critical organ is considered to be that organ of the body whose damage by the radiation results in the greatest damage to the body. It is readily apparent that many factors must be considered in determining which affected organ will cause the body to suffer the greatest damage. Criteria of prime importance are: (a) the organ that accumulates the greatest concentration of the radioactive material; (b) the essentialness or indispensability of the organ to the well-being of the entire body; (c) the organ damaged by the route of entry of the radionuclide into the body; and (d) the radio-sensitivity of the organ, e.g. the organ damaged by the lowest dose. Theoretically all of these considerations are taken into account through the use of the RBE factors and the basic standards (a), (b) and (c) of Section II.2, but it is apparent that the information they represent does not embody much detail on most of the above criteria. Actually, except for a few radionuclides, case (a) above is the determining factor in choosing the critical body organ. For this revision, each radionuclide was studied individually. For some radionuclides as many as twelve reasonable choices of a critical organ were made with the corresponding permissible body burden and concentration values calculated for each organ. These

are listed in Table 1 with the critical organ (or organs in the case of identical MPC values) and minimal MPC values in bold-face type. For each isotope the MPC values are listed first for soluble materials and then for insoluble materials. The values for soluble materials are ranked according to magnitude of $(MPC)_w$ so that the first line in this group designates the critical organ determined solely on the basis of $(MPC)_w$. The values for insoluble materials are ranked according to the magnitude of $(MPC)_a$. The rankings based on $(MPC)_a$ and on $(MPC)_w$ may differ in some cases, so the smallest MPC in each group is in bold-face type to indicate it as a maximum permissible occupational exposure level for plant operation under the stated conditions. The MPC values for other additional organs (termed organs of reference in Table 1) are given primarily as an aid in estimating MPC values for mixtures of radionuclides, and thus, are not permissible levels for the single radionuclide unless in bold-face type.

The total body is listed as an organ of reference for all nuclides except a few of the inert gases. These values are included primarily as an aid in computing MPC values for mixtures, and as a check on the oversimplified model used. As mentioned in (e) on p. 8, this one compartment model is selected to represent the long-term retention in the critical organ and may not represent adequately the situation in other organs. For example, radium and strontium are long-term bone-seekers, but during the first day or two following ingestion appreciable amounts are present in the plasma and soft tissues. This amount is negligible so far as the 50 year accumulation in the bone is concerned, but a check is necessary to determine that the whole body limit is not exceeded by the amount present in the plasma and soft tissues. When present in a mixture, perhaps with other isotopes that concentrate primarily in the soft tissues, the dose delivered by this component of the total retention should not be neglected. The MPC based on total body also supplies a ready means of estimating the integrated dose, i.e. the dose to the body as a whole. While the basic rules do not directly limit the integrated dose except in the case of whole body irradiation, it is of considerable interest. Because the total body limit for constant level exposure is based on 5 rems/year (0.1 rem/week), the total body is sometimes the critical organ. Because the GI tract often receives a greater absorbed dose than any other body organ, and is frequently the critical organ for exposure to mixed fission products, it is with few exceptions included as an organ of reference for the radionuclides in Table 1.

IV. CALCULATION OF MAXIMUM PERMISSIBLE EXPOSURE VALUES

1. Basis for estimating maximum permissible exposure values. As indicated in the above discussion of the basic standards for maximum permissible internal exposure, two somewhat different criteria commonly are used in determining maximum permissible exposure values: (a) for bone-seeking radionuclides such as Sr^{90}, Pu^{239}, etc., which emit significant amounts of particulate radiation, the estimate is based on a comparison with Ra^{226} and daughter products; and (b) for all other radionuclides, the MPC and body burden values are set to limit the weekly RBE dose received by the various organs of the body*, e.g. 0.1 rem/week to the gonads and total body, 0.6 rem/week to the skin and thyroid, and 0.3 rem/week to all other soft tissues. Thus, for a

* In the case of long-lived radionuclides of uranium, the toxic effects set the limiting body burden.

bone-seeker, such as Sr^{85}, which emits only γ- or X-rays, the calculation must be based on 0.3 rem/week since the adjacent soft tissues are also irradiated to approximately the same extent as bone. The first method is the result of a calculation designed to determine, (i) the amount (μc) deposited in the bone that will deliver the same effective RBE dose as delivered by 0.1 μc of Ra^{226} and its daughter products and (ii) the amount (μc) deposited in the bone that will result in damage comparable to that observed from known deposits of Ra^{226} in the bone. In some cases, this first method rests on rather extensive clinical experience or studies of biological damage, either with the particular radionuclide, or with another radionuclide having similar chemical properties and similar metabolic behavior in the body. The method based on RBE dose rate is used generally when bone is not the critical organ or when direct experience is not available. The biological evidence supporting the limits on RBE dose to the various organs of the body is less direct than clinical observation or studies of biological damage, but is consistent with general experience involving radiation from both external and internal sources.

2. *Body burden based on comparison with radium.* In the case of α- and β-emitting radionuclides that localize in the bone, the maximum permissible body burden, q, is determined from a direct comparison with Ra^{226}. In 1941 an advisory committee[12] to the National Bureau of Standards first established the maximum permissible body burden for radium at 0.1 μg ($\sim$0.1 μc). Man has had years of experience with radium, which is the basis of reference in choosing the maximum permissible body burden of similar radionuclides that are deposited in the bone. The radium dial painters, patients treated medically with radium and persons using public water supplies relatively rich in radium[13] have furnished the best source of continuous human exposure from which to observe the effects of an internally deposited radionuclide. From autoradiographic studies[14] of human autopsy material, radium is known to be unevenly distributed in the bone, but other bone-seeking radionuclides may be even less uniformly distributed.[15] From animal experiments[16] it is known that some bone-seeking radionuclides produce greater damage to the bone than Ra^{226} for the same RBE dose. This greater damage is attributed to several factors, some of which are (a) non-uniform distribution, (b) greater radiosensitivity of the portion of bone in which the isotope is deposited, and (c) greater essentialness of the damaged tissue. Therefore a relative damage factor, n, is introduced into the MPC calculation to make some allowance both for the greater relative effectiveness of some radionuclides as well as for the fact that many have a more heterogeneous distribution in bone than radium. The relative damage factor, n, in the formula for effective energy, $\Sigma E_i F_i\,(\mathrm{RBE})_i n_i$ is taken as one provided (a) the parent element of the chain considered is an isotope of radium, or (b) if the energy component considered originates as X- or γ-radiation. The relative damage factor is taken as 5 in all other cases, i.e. if the parent element of the chain is not an isotope of radium and if the energy component considered originates as α-, β^--, β^+-, e^-- radiation or from a recoil atom. Thus, the first two elements in the Th^{228} chain are $Th^{228} \xrightarrow{\alpha,\gamma} Ra^{224} \xrightarrow{\alpha,\gamma}$ and the value of n is 5 for the energies of both these α-particles. In the chain $Ra^{228} \xrightarrow{\beta} Ac^{228} \xrightarrow{\beta,\gamma} Th^{228} \xrightarrow{\alpha,\gamma} Ra^{224} \xrightarrow{\alpha,\gamma}$ the same two α-energies are weighted with $n = 1$. The γ-energy is always weighted with $n = 1$.

When the necessary data are available, the maximum permissible body burden, q, of a radionuclide may be determined by a comparative study of the clinical findings and biological damage produced by various quantities of Ra^{226} and the radionuclide under study. Studies of chronic exposure[17]—a few of which have been started—should furnish the most direct and reliable values of q. Until these studies have been completed, it will be necessary to continue to determine values of q by a direct comparison of the energy deposited in bone by the particular radionuclide with the energy deposited by 0.1 μc of Ra^{226} and its daughter products (with an RBE of 10), modified by the factor, n. In this case, the value of q is given by the equation

$$q = \frac{q^{Ra} f_2^{Ra}}{f_2} \times \frac{\varepsilon^{Ra}}{\varepsilon} = \frac{0.1\ (0.99)}{f_2} \times \frac{110}{\varepsilon} = \frac{11}{f_2 \varepsilon} \qquad (1)$$

in which

$q^{Ra} = 0.1$ μc is the maximum permissible body burden of Ra^{226};

f_2 = fraction of radionuclide in the skeleton of that in the total body; $f_2^{Ra} = 0.99$ is the value of f_2 for radium;

ε = effective absorbed energy per disintegration of a radionuclide = $\Sigma EF(\text{RBE})n$; $\varepsilon^{Ra} = 110$ is the value of ε for radium;

E = energy (MeV) deposited in skeleton per disintegration;

RBE = relative biological effectiveness = 1 for X, γ, β^-, β^+, e^-, (it is set equal to 1.7 if the maximum energy, $E_m \leqslant 0.03$ MeV for β^-, β^+ or e^-), 10 for α and 20 for recoil atoms;

F = ratio of disintegrations of daughter to disintegrations of parent. See Section V.1.

It is assumed that 99 per cent of the radium in the body is in the skeleton, and the total energy deposited in the skeleton per disintegration of Ra^{226} plus 30 per cent of its daughter products[18, 19] is 11 MeV, and thus the effective energy deposited in the skeleton is $\Sigma EF(\text{RBE})n = 110$*. For other radionuclides which are localized in the bone, the effective absorbed energy is found from $\Sigma EF(\text{RBE})n$.

Thus, 0.1 μc of Ra^{226} and its daughter products in the body corresponds to an average absorbed dose rate to the bone of 0.06 rad/week or an average dose rate to the bone of 0.56 rem/week. As indicated above, the factor, n, was set equal to 1 in arriving at these dose rates for Ra^{226}. The distribution of radium in bone is not uniform,[14] and, for example, if there are portions of the bone in which radium is concentrated, the dose rate in these areas might be many times the average values. These values of RBE dose rate are based on the assumption that $(\text{RBE})_\alpha = 10$. Many experiments[20] indicate that $(\text{RBE})_\alpha$ is much smaller than 10 for biological damage resulting from acute exposure—perhaps as small as 1.4—but for biological damage from chronic exposures much higher applicable values have been reported.[21] Therefore, until more data from chronic exposures are available it would be unwise to use a value of $(\text{RBE})_\alpha < 10$. Occupational and medical experience with radium offers much more justification for accepting the 0.1 μc of Ra^{226} and for the RBE dose

* This value was given as 162 MeV in the 1955 ICRP report[2] but is changed to 110 MeV in this 1958 edition. The reduction to 110 MeV is the result of using the more recent data of NORRIS[18] which indicate a bone retention of 30 per cent of the daughter products of Ra^{226}. The earlier data of EVANS [19] which assumed 55 per cent retention of the daughter products of Ra^{226} had been used to obtain the 162 MeV. Details of calculation of this effective absorbed energy are given in Section V.1.

it delivers to the bone as a basic reference for permissible occupational exposure than any arbitrarily chosen dose rate to individual organs. At this time, it would be difficult to say which is more harmful to man, (a) the dose rate to the total body of 0.1 rem/week, or (b) the dose rate to the bone resulting from a body burden of 0.1 μc of Ra^{226}. Certainly, if a major portion of the hematopoietic system were irradiated, e.g. concurrently from the spleen-seeking Po^{210} and from the bone-seeking Ra^{226}, the biological damage would be greater than if only a part of it were irradiated. It has been shown[8] that in some cases a synergistic effect results when several organs of the body are irradiated simultaneously. Thus, it is rather certain that 0.1 rem/week to the bone is less harmful than 0.1 rem/week to the total body but, at present, sufficient quantitative data are lacking to indicate whether or not an average dose rate of 0.56 rem/week (involving, perhaps, a much higher local dose rate) to the bone produces greater or less damage than 0.1 rem/week to the entire body.

The development of bone tumors many years after exposure (from 10 to 35 years) has been the principal hazard to patients given large medical doses of radium and to the radium dial painters. Although tumors have not been observed in persons with body burdens of radium as low as 0.1 μc, the factor of safety may not be as large as 10 because tumors have occurred in persons having a body burden less than 1μc of radium at the time the tumor was first detected. However, in all these cases the original body burden had been greater than it was when the tumor was first detected. Furthermore, in most cases the integrated absorbed dose received by the radium dial painters had been much enhanced because a large amount of mesothorium (Ra^{228}) was in the ingested material. There is an additional factor of safety in the MPC values for the long-lived radionuclides in Table 1 in that the maximum permissible body burden is reached only after an extended exposure at the MPC level (see Section III.1). For the radionuclides (Table 2) with a long effective half-life, e.g. Ra^{226}, Th^{230}, Th^{232}, Np^{237}, Pu^{239}, Am^{243}, Cm^{246}, etc., the maximum permissible body burden is not reached until after 50 years of continuous occupational exposure. Several workers[22] have described changes in skeletal density and/or histopathological changes in the bone of patients who have 0.1 μc or less of radium, and more pathological changes may be expected as these individuals become older. This problem will be kept constantly under advisement, and as more data are accumulated on the chronic effects of radium and other bone-seeking radionuclides, it may be desirable at a later date to lower the basic reference of 0.1 μc of Ra^{226}. However, at the present time, this change does not seem to be warranted for reasons as follows: (a) radium does not irradiate the entire hematopoietic system; (b) body burdens of 0.1 μc of Ra^{226} probably produce detectable changes in the bone but are not known to have caused serious damage (demonstrable harm to the individual); (c) the principal recognizable damage from Ra^{226} is the production of bone tumors, but the lowest body burden that has resulted in a tumor is 0.5 μc;[23] (d) all radium-produced tumors have occurred in persons whose original body burdens had been much greater than at the time the tumors were discovered; (e) most bone tumors arising in radium dial painters may be attributed to $Ra^{226} + Ra^{228}$ in which the integrated RBE dose was much greater than would be indicated by the Ra^{226} burden at the time the tumors were discovered; and (f) the maximum permissible body burden of a bone-seeking radionuclide corresponding to 0.1 μc

of Ra^{226} is not reached except following continuous occupational exposure at the MPC values. For the more dangerous bone-seeking radionuclides, this requires continuous occupational exposure for 50 years at the MPC level.

3. Body burden based on a permissible RBE dose rate to the critical body organ. Because specific experimental information is lacking for assessing values of safe body burdens of the radionuclides that are not localized in the bone, the MPC and q values were calculated on the premise that a maximum permissible body burden is that amount distributed throughout the body that will result in a maximum permissible RBE dose rate to the critical organ. The maximum RBE dose rates permitted to the various body organs are listed in Section II.2. It should be emphasized that these maximum permissible RBE dose rates are values averaged during a quarter. Variations of these rates over shorter intervals may be expected and are permissible. As explained in Section II, the average dose rate of 0.1 rem/week and corresponding MPC values for occupational exposure of the gonads or total body may be increased over a 13 week period by a factor as large as 2.4, provided the dose at any age N does not exceed that given by the formula $5(N-18)$ and provided adequate monitoring is used to insure that the dose in a 13 week period does not exceed 3 rems.

In the following discussion, the distribution of the isotope in the body is characterized by the following parameters:

f_1 = the fraction of ingested radionuclides reaching the blood;
f_2' = the fraction of the nuclide in the blood that reaches the organ of reference;
$f_w = f_1 f_2'$, see Section V.3;
f_a = the fraction of inhaled radionuclide reaching the organ of reference, see Section V.3;
f_2 = the fraction of the body burden in the organ of reference, see Section V.3.

The equation for maximum permissible body burden, q, based on a maximum permissible dose rate R rem/week is

$$q = \frac{100\, mR}{3.7 \times 10^4 \times 1.6 \times 10^{-6} \times 6.05 \times 10^5 f_2 \varepsilon} \tag{2}$$

$$q = \frac{2.8 \times 10^{-3}\, m\, R}{f_2\, \varepsilon} \tag{3}$$

and when $R = 0.3$ rem/week

$$q = \frac{8.4 \times 10^{-4}\, m}{f_2 \varepsilon} \tag{4}$$

where 3.700×10^4 = dis/sec per μc;
1.6×10^{-6} = ergs/MeV;
6.05×10^5 = sec/week;
100 = ergs/g per rad;
m = mass of the organ of reference (g);
and ε is defined as for equation (1).

4. Concentrations in air and water—based on exponential model—critical organs other than gastrointestinal (GI) tract. Maximum permissible concentrations in air and in water in Table 1 were calculated for most of the radionuclides on the assumption that the radioactive material is taken into the critical body organ at the rate of P μc/day and that the biological elimination from the critical organ follows a simple exponential law. This relationship is expressed by the equation;

$$\frac{d(qf_2)}{dt} + \lambda(qf_2) = P \tag{5}$$

The solution with $qf_2 = 0$ when $t = 0$ is

$$qf_2 = P(1 - e^{-\lambda t})/\lambda \tag{6}$$

in which qf_2 = burden of the radionuclide in the critical body organ (μc);

f_2 = fraction of radionuclide in critical organ of that in total body;
λ = effective decay constant = $0.693/T$;
T = effective half-life $(T_r T_b)/(T_r + T_b)$ (days);
T_r = radioactive half-life (days);
T_b = biological half-life (days);
t = period of exposure; for occupational exposure $t = 50$ years (in the previous publications of NCRP[1] and ICRP[2] t was set to equal 70 years);
P = rate of uptake of the radionuclide by the critical body organ (μc/day) = $(M)S$, where M is the concentration (μc/cm³) of the radionuclide in water or in air taken into the body, and S is the product of the average rate of intake (cm³/day) of water or of air and the fraction of the microcuries arriving in the critical body organ. For occupational exposure at the maximum permissible concentration (MPC) of the radionuclide in water, $M = (\text{MPC})_w$ and in air, $M = (\text{MPC})_a$. In a 24 hr day, the standard man (see Section V.2 for a discussion of the standard man) consumes 2200 cm³ of water and breathes 2×10^7 cm³ of air. Because of his greater activity during an 8 hr work day, it is assumed that half of this body intake occurs during the work period, viz. 1100 cm³ of water and 10^7 cm³ of air. The work schedule for the standard man is 8 hr/day, 5 days/week and 50 weeks/year. Therefore for the average occupational exposure, $S = 1100 \times 5/7 \times 50/52 f_w = 750\ f_w$ cm³ of water per day and $S = 10^7 \times 5/7 \times 50/52 f_a = 6.9 \times 10^6 f_a$ cm³ of air per day.

The formulas that follow in this section are all based on a 40 hr/week exposure period whenever specific time data are involved. For continuous occupational exposure the MPC values should be divided by $2 \times 365/(5 \times 50) = 2.92$ except

for submersion where they should be divided by $3 \times 365/(5 \times 50) = 4.38$. Substituting the above values for P and λ in equation (6) the MPC values are determined by

$$(\text{MPC})_a = \frac{10^{-7}\, q f_2}{T f_a\,(1 - e^{-0.693\, t/T})}\ \mu\text{c/cm}^3 \tag{7}$$

and

$$(\text{MPC})_w = \frac{9.2 \times 10^{-4}\, q f_2}{T f_w\,(1 - e^{-0.693\, t/T})}\ \mu\text{c/cm}^3 \tag{8}$$

T = effective half-life (days);
t = period of exposure (days).

If the radionuclide disintegrates into one or more daughter radionuclides, proper account must be taken of the contribution to the RBE dose by the daughter radionuclides that are produced in the body. Formulas (7) and (8) may be modified so that they remain correct for a chain of parent–daughter radionuclides. This can be done by simply augmenting the effective energy of the parent by the effective energy of each daughter weighted by the frequency of the daughter disintegrations per disintegration of parent. This ratio defines the factor F_i, i.e.

$$F_i = \frac{\mu\text{c of } i\text{th daughter in the organ}}{\mu\text{c of parent in the organ}}$$

Thus in the case[24] of a single intake, if P μc of the parent radionuclide reaches the critical organ at time $t = 0$, the organ burden $(q f_2)_i^s$ of the ith daughter product at time t is given by the equation

$$(q f_2)_0^s = P\, e^{-\lambda_0 t}$$

$$(q f_2)_1^s = P\, \lambda_1^r \left[\frac{e^{-\lambda_0 t}}{\lambda_1 - \lambda_0} + \frac{e^{-\lambda_1 t}}{\lambda_0 - \lambda_1}\right]$$

$$(q f_2)_2^s = P\, \lambda_1^r \lambda_2^r \left[\frac{e^{-\lambda_0 t}}{(\lambda_1 - \lambda_0)(\lambda_2 - \lambda_0)} + \frac{e^{-\lambda_1 t}}{(\lambda_0 - \lambda_1)(\lambda_2 - \lambda_1)} + \frac{e^{-\lambda_2 t}}{(\lambda_0 - \lambda_2)(\lambda_1 - \lambda_2)}\right]$$

The general formula is

$$(q f_2)_i^s = P\left[\prod_{j=1}^{i} \lambda^r\right] \sum_{h=0}^{i} \frac{e^{-\lambda_h t}}{\prod_{\substack{p=0 \\ p \neq h}}^{i} (\lambda_p - \lambda_h)} \tag{9}$$

In this formula $\left[\prod_{j=1}^{i} \lambda_j^r\right]$ denotes the product $\lambda_1^r \times \lambda_2^r \times \ldots \times \lambda_i^r$.

If it is understood that when $i = 0$ the empty product $\left[\prod_{j=1}^{0} \lambda_j^r\right]$ is equal to 1, this general formula (9) is applicable to the total body burden of the parent as well as the daughter radionuclides. In the following discussion, the subscript, 0, as in $\lambda_0^r = 0.693/T_0^r$, etc., always refers to the parent isotope while the subscript i indicates the decay constants of the ith daughter.

When there is continuous intake of the parent radionuclide so that P μc/day of the parent radionuclide reaches the critical organ, the organ burden $(qf_2)_i$ of the ith daughter product at time t is given by the equation:

$$(qf_2)_0 = P(1 - e^{-\lambda_0 t})/\lambda_0$$

$$(qf_2)_1 = P\,\lambda_1^r \left[\frac{(1 - e^{-\lambda_0 t})}{\lambda_0(\lambda_1 - \lambda_0)} + \frac{(1 - e^{-\lambda_1 t})}{\lambda_1(\lambda_0 - \lambda_1)}\right]$$

$$(qf_2)_2 = P\,\lambda_1^r\lambda_2^r\left[\frac{(1 - e^{-\lambda_0 t})}{\lambda_0(\lambda_1 - \lambda_0)\,(\lambda_2 - \lambda_0)} + \frac{(1 - e^{-\lambda_1 t})}{\lambda_1(\lambda_0 - \lambda_1)\,(\lambda_2 - \lambda_1)} + \frac{(1 - e^{-\lambda_2 t})}{\lambda_2(\lambda_0 - \lambda_2)\,(\lambda_1 - \lambda_2)}\right]$$

The general formula is

$$(qf_2)_i^s = \int_0^t (qf_2)_i^s\, dt = P\left[\prod_{j=1}^{i} \lambda_j^r\right] \sum_{h=0}^{i} \frac{1 - e^{-\lambda_h t}}{\lambda_h \prod_{\substack{p=0 \\ p \neq h}}^{i} (\lambda_p - \lambda_h)} \tag{10}$$

It is to be noted that equation (10) includes equation (6) as a special case if it is understood that when $i = 0$ the empty product is replaced by 1. The dose rate in rems/week to the critical body organ resulting from the continuous body intake and deposition of the parent radionuclide and from the growth of the daughter radionuclides in the critical body organ is given by the equation:

$$R = \sum_{i=0}^{k} (qf_2)_i \frac{3.7 \times 10^4 \times 24 \times 3600 \times 7 \times 1.6 \times 10^{-6}\, E_i\, (\mathrm{RBE})_i n_i}{100\, m} \text{ rems/week} \tag{11}$$

in which m is the mass of the critical organ, and $E_i\,(\mathrm{RBE})_i n_i$ is the effective energy corresponding to one disintegration of an ith daughter atom. The factor P is taken as $6.9 \times 10^6 \times (\mathrm{MPC})_a f_a$ for inhalation and as $750\,(\mathrm{MPC})_w f_w$ for ingestion, and since the factor P occurs in each of the (qf_2) terms in equation (11), and since $(qf_2)_0 = P(1 - e^{-\lambda_0 t})/\lambda_0$

$$(\mathrm{MPC})_a = \frac{4.1 \times 10^{-10}\, m\, R}{f_a \sum_{i=0}^{k} (qf_2)_i\, E_i\, (\mathrm{RBE})_i n_i / P}\ \mu\mathrm{c/cm^3} = \frac{4.1 \times 10^{-10}\, m\, R\, \lambda_0}{f_a(1 - e^{-\lambda_0 t}) \sum_{i=0}^{k} E_i F_i (\mathrm{RBE})_i n_i}\ \mu\mathrm{c/cm^3} \tag{12}$$

$$(\mathrm{MPC})_w = \frac{3.7\times10^{-6}\,mR}{f_w \sum_{i=0}^{k} (qf_2)_i E_i (\mathrm{RBE})_i n_i / P}\ \mu\mathrm{c/cm^3} = \frac{3.7\times10^{-6}\,m\,R\,\lambda_0}{f_w(1-e^{-\lambda_0 t}) \sum_{i=0}^{k} E_i F_i (\mathrm{RBE})_i n_i}\ \mu\mathrm{c/cm^3} \quad (13)$$

with $F_0 = 1$ and $F_i = (qf_2)_i/(qf_2)_0$. In equations (12) and (13) R is the permissible dose rate to the organ in rems/week. Thus if particulate radiation is involved R=0.56 when bone is the critical organ and $R = 0.3$ for all other organs except thyroid and skin, in which cases $R = 0.6$ or for total body and gonads where $R = 0.1$. The weighted sum of chain energies $\Sigma E_i F_i$ $(\mathrm{RBE})_i n_i$ and the fractions F_i are listed in Table 5(a). In all organs other than bone n_i is taken as 1. Equations (12) and (13) are based on the 40 hr week. The corresponding formulas for the 168 hr week, i.e. continuous exposure, are obtained by replacing the constants 4.1×10^{-10} and 3.7×10^{-6} by 1.4×10^{-10} and 1.3×10^{-6}, respectively.

5. Concentrations in air and water based on RBE dose delivered to various segments of the GI tract. When the critical organ considered is the gastrointestinal (GI) tract, the amount (μc) of the ith daughter present at time t is given by formulas similar to equation (9), but since the material moves along the intestines at somewhat different rates, formula (11) also needs adjustment. If τ is the total time spent in a section of the GI tract, e.g. the upper large intestine, then during a time interval $d\tau$ the fraction of the total contents which moves by a given site is, on the average, $d\tau/\tau$. The mass of this material is thus $d\tau/\tau \times m$, where m is the total mass of the contents of the section being considered. The energy is, to a first approximation, absorbed in this mass. Thus if there is continuous intake of P μc/day, then the dose rate in rems/week to the walls of the GI tract near the site is given by

$$R = \sum_{i=0}^{k} (qf_2)_i^{\ \mathrm{total}} \frac{3.7 \times 10^4 \times 24 \times 3600 \times 7 \times 1.6 \times 10^{-6} \varepsilon_i\, d\tau}{2 \times 100\, m \times d\tau/\tau}\ \mathrm{rems/week} \quad (14)$$

In the case of an isotope with no daughters, the value of $(\mathrm{MPC})_a$ is

$$(\mathrm{MPC})_a = \frac{8.2 \times 10^{-10}\, m\, R}{f_a \tau \varepsilon_0 e^{-\lambda_0 t}}\ \mu\mathrm{c/cm^3} \quad (15)$$

and the value of $(\mathrm{MPC})_w$ is

$$(\mathrm{MPC})_w = \frac{7.4 \times 10^{-6}\, m\, R}{\tau \varepsilon_0 e^{-\lambda_0 t}}\ \mu\mathrm{c/cm^3} \quad (16)$$

If the radionuclide considered is the parent of a chain of k daughters, the corresponding formula for $(\mathrm{MPC})_a$ is

$$(\mathrm{MPC})_a = \frac{8.2 \times 10^{-10}\, m\, R}{\tau f_a \sum_{i=0}^{k} \frac{(qf_2)_i^{\ \mathrm{total}}}{P}\ \varepsilon_i}\ \mu\mathrm{c/cm^3} \quad (15')$$

and the value of $(\mathrm{MPC})_w$ is

$$(\mathrm{MPC})_w = \frac{7.4 \times 10^{-6}\, m\, R}{\tau \sum_{i=0}^{k} \frac{(qf_2)_i^{\text{total}}}{P}\, \varepsilon_i} \ \mu\mathrm{c/cm^3} \tag{16'}$$

The values of the biological constants used for the different sections of the GI tract are listed in Table 11. Since daughter elements also enter the small intestine and the large intestine, each subdaughter is the parent for a subchain and $(qf_2)_i^s$ must be computed by equation (9) for all such subchains and the results added to give the amount of ith daughter in the organ. This will be denoted by $(qf_2)_i^{\text{total}}$. A factor of $\frac{1}{2}$ has been included in formulas (14) through (19′) to take account of the fact that the dose to the intestinal wall is, on the average, only half the dose to the contents of the GI tract. In equations (15′) and (16′) $(qf_2)_i^{\text{total}}$ represents the amount of the ith isotope (μc) (equation (9)), and the formulas were computed in this form. Thus the factors F_i are not needed and since the relative damage factor $n_i = 1$ for the GI tract, the effective energy reduces to $\varepsilon_i = \Sigma E$ (RBE) which is tabulated in Tables 5 and 5(a). Experiments[25] have shown that α-particles fail to penetrate the mucosa to an appreciable extent. Therefore, the Committee has decided to include only 1 per cent of the energy of the α-particles in computing the effective energies, $\Sigma\varepsilon_i$, for the GI tract. In calculating $(qf_2)_i^{\text{total}}$ it is assumed that there is no absorption of the material from the large intestine, and thus $\lambda_i^b = 0$ and $\lambda_i = \lambda_i^r$ in these sections of the tract. The same is assumed for the stomach. In the small intestine a fraction f_1 is absorbed and a value of λ_i^b is chosen so that absorption at this constant rate during the time of passage amounts to a total absorption of a fraction f_1 of the material. Equations (15) and (16) are applied when the critical portion of the GI tract is the small intestine, SI, upper large intestine, ULI, or the lower large intestine, LLI. Since the upper large intestine and the lower large intestine have the same diameter, the effective energy is the same for these two sections. This common value is listed in Tables 5 and 5(a) as the value for the large intestine, LI. The calculations for the stomach, S, are somewhat different since it is assumed that the ingested material remains in the stomach for 1 hr. Thus, the dose to the stomach is given by

$$R = \sum_{i=0}^{k} \int_0^{1/24} \frac{(qf_2)_i^s \times 3.7 \times 10^4 \times 24 \times 3600 \times 7 \times 1.6 \times 10^{-6}\, \varepsilon_i\, d\tau}{2 \times 100\, m} \text{ rems/week} \tag{17}$$

In the case of an isotope with no daughters the value of $(\mathrm{MPC})_a$ is

$$(\mathrm{MPC})_a = \frac{2.5 \times 10^{-10}\, m\, \lambda_0}{f_a\, \varepsilon_0\, (1 - e^{-\lambda_0/24})} \ \mu\mathrm{c/cm^3} \tag{18}$$

and the value of $(\mathrm{MPC})_w$ in this case is

$$(\mathrm{MPC})_w = \frac{2.2 \times 10^{-6}\, m\, \lambda_0}{\varepsilon_0\, (1 - e^{-\lambda_0/24})} \ \mu\mathrm{c/cm^3} \tag{19}$$

If the radionuclide considered is the parent of a chain of k daughters and the stomach is the critical tissue, the corresponding formula for $(\mathrm{MPC})_a$ is

$$(\mathrm{MPC})_a = \frac{2.5 \times 10^{-10}\, m}{f_a \sum_{i=0}^{k} \varepsilon_i \left[\prod_{j=1}^{i} \lambda_j^r\right] \sum_{h=0}^{i} \dfrac{(1 - e^{-\lambda_h/24})}{\lambda_h \prod_{\substack{p=0 \\ p \neq h}}^{i} (\lambda_p - \lambda_h)}} \ \mu c/cm^3 \qquad (18')$$

and the value of $(\mathrm{MPC})_w$ when the stomach is the critical tissue is

$$(\mathrm{MPC})_w = \frac{2.2 \times 10^{-6}\, m}{\sum_{i=0}^{k} \varepsilon_i \left[\prod_{j=1}^{i} \lambda_j^r\right] \sum_{h=0}^{i} \dfrac{(1 - e^{-\lambda_h/24})}{\lambda_h \prod_{\substack{p=0 \\ p \neq h}}^{i} (\lambda_p - \lambda_h)}} \ \mu c/cm^3 \qquad (19')$$

The notation in formulas (18) through (19′) is chosen in agreement with the notation of formula (10) on which these are based. However, as explained above, no absorption occurs in the stomach so that $\lambda_i^b = 0$ and thus λ_i in formulas (18) through (19′) is equal to λ_i^r, i.e. $\lambda_i = \lambda_i^r + \lambda_i^b = \lambda_i^r + 0 = \lambda_i^r$. For some isotopes the dose rate to the intestinal wall passes through a maximum value during the time of passage through the GI tract, and thus it is necessary to determine this maximum and equate it to 0.3 rem/week in determining the maximum permissible intake. The use of the single intake formulas for $(qf_2)_i^s$ and $(qf_2)_i^{\text{total}}$ in equations (14) through (19′) instead of continuous intake formulas for the organ burden as in equations (10) through (13) follows from the fact that by our assumption of continuous movement at a uniform rate through each section of the tract the isotope never accumulates in the GI tract, and thus the dose at a position reached at time t after ingestion of material is entirely independent of what material was ingested before time $t = 0$ or following time $t = 0$. This is, of course, an oversimplification since there is some irradiation of one portion of the GI tract by any γ-radiation in the body and, perhaps, by some β-rays emitted in other portions of the tract. To a large extent this is taken into account in computing the effective energies, ε_i, which are calculated for each section of the tract as a whole and not merely for a very small portion of the tract.

6. Maximum permissible concentration of radionuclides of noble gases and other relatively inert gases. In dealing with inert gases, such as A^{41} and Xe^{135}, the calculations are not based on the dose delivered by the concentration of the radioactive material inside the body, but rather on the dose the person would receive if he were surrounded by a semispherical infinite cloud of radioactive gas. In this case, one would expect the radiation from the radioactive cloud to deliver a much higher dose than that from the gas held in the lungs or other body organs. It follows that the body is assumed to be irradiated from half the solid angle by this radioactive cloud of large volume.

The maximum permissible concentration of an inert gas under these conditions is,

$$(\mathrm{MPC})'_a = \frac{0.024\,R}{\Sigma\,(E)}\,\rho_a\,P_a/P_t\,\mu\mathrm{c/cm^3} \tag{20}$$

When the maximum permissible dose rate R is 0.1 rem/week,

$$(\mathrm{MPC})'_a = \frac{2.6 \times 10^{-6}}{\Sigma\,(E)}\,\mu\mathrm{c/cm^3} \tag{21}$$

in which ρ_a = density of air ($= 0.0012$ g/cm^3);

P_a/P_t = stopping power of air relative to tissue; $P_a/P_t = 1/1.13$ for β and secondary electrons produced by X- and γ-radiation;

$\Sigma\,(E)$ = effective energy per disintegration (MeV); in this case RBE = 1 and $n = 1$;

$(\mathrm{MPC})'_a$ = maximum permissible concentration (μc/cm^3) in a large cloud of gas that will deliver a dose at the rate of 0.1 rem/week.*

Equation (21) is applied only in the case of large clouds of noble gases or other relatively inert gases that emit γ or high energy β-radiation ($E_m \geqslant 0.1$ MeV). This equation is applicable to occupational exposure (i.e. 40 hr/week) and for the case where a person is surrounded by an infinite semispherical cloud of radioactive material that emits γ-, X- or β-radiation of sufficient energy to constitute essentially a total body exposure and necessitate limiting the dose rate to 0.1 rem/week.

The above formula was not used for noble gases that are principally α-emitters, e.g. Rn^{222} and Rn^{220}, or for other relatively inert gases that emit low energy ($\leqslant 0.1$ MeV) β-radiation, e.g. H_2^3, because the radiation would not penetrate the protective epidermal layer of skin surrounding the body. In the case of such low energy radiation formula (20) still applies but with $R = 0.6$ rem/week. Such cases are listed in Table 1 with "submersion skin" as the organ of reference. Experiments have shown that when HTO vapor is present in air approximately equal amounts enter the body by inhalation and absorption through the skin. Thus the value computed by equation (7) must be halved in this case.

In 1941 the United States Advisory Committee on X-ray and Radium Protection[12] set 10^{-8} μc/cm^3 as the value of $(\mathrm{MPC})_a$ for occupational exposure (40/hr week) to Rn^{222} plus its daughter products. However, the ICRP[2] gave an $(\mathrm{MPC})_a$ value of 10^{-7} μc/cm^3 for continuous exposure (168 hr/week). Despite the wide disparity of these values and the long record of experience with radon, there are few, if any, well-established cases of serious damage from exposures at these levels. Nevertheless, calculations indicate that an air concentration of 10^{-7} μc/cm^3 might lead to an excessively large dose to the bronchi, and the NCRP[1] previously had recommended the value of 10^{-8} μc/cm^3 as $(\mathrm{MPC})_a$ for Rn^{222} plus daughters (168 hr/week).

* In the previous publication of this report,[2] the exposure rate was taken as 0.3 rem/week rather than 0.1 rem/week, and the radioactive cloud was assumed to comprise an infinite sphere rather than an infinite semisphere about the body. Also, the equations were given for continuous exposure rather than for the typical week of work. Therefore, previously published MPC values have been increased by three factors, viz. $1/3 \times 2 \times 4.4 = 2.9$. The new assumptions are thought to be sufficiently conservative in all practical cases.

Recent studies[26] have indicated that when radon and its daughters are present in ordinary air the free ions of RaA constitute only about 10 per cent of the total number of RaA atoms that would be present at equilibrium and these unattached atoms deliver all but a small fraction of the dose to the bronchi. Based on these measured dose rates the $(MPC)_a$ for exposure to radon and daughter products is found to be $3\times 10^{-6}/(1 + 1000f)$ where f is the fraction of the equilibrium amount of RaA ions which are unattached to nuclei.

For Rn^{220} the major portion of the dose to the bronchi is due to free ions of ThB which reach only 1/2000 of the equilibrium number in ordinary unfiltered air. Because of this and energy considerations the $(MPC)_a$ value will be higher and is recommended as $6 \times 10^{-6}/(1 + 40000f)$ if the free ions of ThB constitute a fraction f of the equilibrium number of such atoms. The values given here for radon and daughters and for thoron and daughters are for the 40 hr week.

7. Maximum permissible concentration of unidentified radionuclides (MPCU). The identity of the radioactive contaminants in air, water and food must be established before appropriate MPC values can be applied either for occupational exposure or for exposure to population outside of controlled areas. In many cases there is no question regarding the identity of a radionuclide because the operation involves only one radionuclide. Sometimes, however, preliminary surveys reveal the presence of radioactive contamination, and considerable uncertainty exists as to which radionuclides are the major contributors. When a laboratory is using a number of radionuclides, e.g. mixed fission products, an air sample may furnish only a few clues as to the identity of the radionuclide. By using the simplest of equipment and techniques, the level of air contamination may be established in a matter of minutes, but hours or even days may be required to conduct the radiochemical analyses necessary to identify the one or more radionuclides that are present in the air. Fortunately, in such cases it usually is not necessary to go through a tedious, time consuming and expensive radiochemical analysis. If it is determined that certain of the more dangerous radionuclides are not present, i.e. the concentration of the more dangerous is small compared with the MPC values in Table 1, the operation may be continued safely regardless of the radionuclide or mixture of radionuclides, provided the concentration does not exceed the values for MPC of unidentified (MPCU) radionuclides as listed in Table 3 for water or in Table 4 for air. These MPCU values are applicable to continuous occupational exposure (168 hr/week), and should be multiplied by one-tenth if they are to be applied as interim values outside of and in the neighborhood of the controlled exposure area. It should be pointed out that the use of MPCU values may save an immense amount of effort and expense if they are applied properly to avoid unnecessary radionuclide analyses in areas where the air, water and food contamination is usually less than the appropriate MPCU values. On the other hand, they can impose a needless penalty if improperly applied. For example, if initial measurements indicate a negligible amount of Ra^{226} and Ra^{228} in the drinking water of a small community near an atomic energy laboratory, and if it is determined by daily gross α-, β- and γ-sample counting that the activity does not exceed the MPCU value ($\frac{1}{10} \times 1 \times 10^{-6}\ \mu c/cm^3 = 1 \times 10^{-7}\ \mu c/cm^3$) it would seem foolish to carry out a daily radiochemical analysis of this water. If, on the other hand,

the level ranged between 10^{-5} and 2×10^{-5} $\mu c/cm^3$, it would be unwise to shut down the plant or to instigate an expensive modification of the operation without first identifying the radionuclides, for it might be that the contamination in the water is from Na^{24} and P^{32}. In this case, the appropriate MPC value for application in the neighborhood of the plant is $\frac{1}{10} \times 2 \times 10^{-3} = 2 \times 10^{-4}$ and $\frac{1}{10} \times 2 \times 10^{-4} = 2 \times 10^{-5}$, respectively (see Table 1).

8. Maximum permissible concentration of known mixtures of radionuclides. Suppose a person is exposed to concentrations $\rho_{aA}, \rho_{aB}, \ldots \rho_{wA}, \rho_{wB} \ldots$ $\mu c/cm^3$ of isotopes $A, B, \ldots$ in air and in water, respectively, and also to external sources of γ and neutron radiations. Assume further that the external sources give doses R^x_γ, R^x_n to a given organ x for γ and neutron radiation, respectively. If L^x rem is the average weekly dose permitted to organ x by the basic rules, then the total dose to organ x is

$$\left[\frac{\rho_{aA}}{(\mathrm{MPC})^x_{aA}} + \frac{\rho_{aB}}{(\mathrm{MPC})^x_{aB}} + \ldots + \frac{\rho_{wA}}{(\mathrm{MPC})^x_{wA}} + \frac{\rho_{wB}}{(\mathrm{MPC})^x_{wB}} + \ldots\right] L^x + R^x_\gamma + R^x_n \quad (22)$$

This does not exceed L^x provided

$$\frac{\rho_{aA}}{(\mathrm{MPC})^x_{aA}} + \frac{\rho_{aB}}{(\mathrm{MPC})^x_{aB}} + \ldots + \frac{\rho_{wA}}{(\mathrm{MPC})^x_{wA}} + \frac{\rho_{wB}}{(\mathrm{MPC})^x_{wB}} + \ldots + \frac{R^x_\gamma}{L^x} + \frac{R^x_n}{L^x} \leqslant 1 \quad (23)$$

and thus provides a criterion for assessing whether or not the exposure is in excess of that permitted by the basic rules. If organ x is not listed as an organ of reference in Table 1, and if an independent estimate of the corresponding MPC values is not available, the MPC based on total body may be used with the correction factor $L^x/0.1$, i.e. $L^x(\mathrm{MPC})^{T.B.}_a/0.1$ may be substituted for $(\mathrm{MPC})^x_a$ in such cases. In general it will be necessary to calculate the dose for all the organs for which the dose may reasonably be considered to be in excess of the prescribed limits. Often this may include the total body even though no one of the radionuclides irradiates a major portion of the body. Assuming that a major portion of the body is being irradiated at somewhat comparable rates, the calculation is essentially as before except that the MPC values based on total body are to be used. Thus the criterion is

$$\frac{\rho_{aA}}{(\mathrm{MPC})^{T.B.}_{aA}} + \frac{\rho_{aB}}{(\mathrm{MPC})^{T.B.}_{aB}} + \ldots + \frac{\rho_{wA}}{(\mathrm{MPC})^{T.B.}_{wA}} + \frac{\rho_{wB}}{(\mathrm{MPC})^{T.B.}_{wB}} + \ldots + \frac{R^{T.B.}_\gamma}{0.1} + \frac{R^{T.B.}_n}{0.1} \leqslant 1 \quad (24)$$

In effect this limits the average dose rate over the body to 0.1 rem/week. There may be some organs in which the dose rate exceeds 0.1 rem/week, but this is considered permissible so long as such organs do not constitute a major portion of the body. Of

course, the criteria for these organs must also be considered, and the application of equation (23) will prevent any particular organ from exceeding the permissible limit set for that organ. However, it would seem too conservative and contrary to the intent of the basic rules to limit the dose to any portion of the body to a maximum rate of 0.1 rem/week merely because the entire body is receiving some dose, though it may be very small in most of the body and only be at the rate of 0.1 rem/week in a small portion. The values of $(\mathrm{MPC})^{T.B.}$ as given in Table 1 and as applied in equation (24) were derived on the assumption that the total body dose of interest in this case is the gram-rem dose or the total weighted energy delivered to the total body. On this basis the total body burden was obtained from equation (3) by setting m equal to the mass of the total body ($m = 70{,}000$ g), $f_2 = 1$, ε equal to the weighted absorbed energy, $n = 1$ and $R = 0.1$ rem/week.

The application of these criteria may be illustrated by the following example: Suppose the mixture consists of Sr^{90}, Pu^{239} and Na^{24}, and that an external γ-source is also present, and that the measured intensities are those indicated in Table *A*.

Table A. Calculation of MPC of a mixture of radionuclides

Example of Concurrent Exposure to Several Radionuclides (in Soluble Form) Present in Air and Water and to an External Source of Radiation

Source of exposure	Body organ exposed	In air*	In water*
Sr^{90}	Bone	$\frac{\rho_{aA}}{(\mathrm{MPC})^{x}_{aA}} = \frac{1.8\times10^{-11}\ \mu c/cm^3}{3\times10^{-10}\ \mu c/cm^3}$	$\frac{\rho_{wA}}{(\mathrm{MPC})^{x}_{wA}} = \frac{1.5\times10^{-7}\ \mu c/cm^3}{4\times10^{-6}\ \mu c/cm^3}$
	Total body	$\frac{\rho_{aA}}{(\mathrm{MPC})^{T.B.}_{aA}} = \frac{1.8\times10^{-11}\ \mu c/cm^3}{9\times10^{-10}\ \mu c/cm^3}$	$\frac{\rho_{wA}}{(\mathrm{MPC})^{T.B.}_{wA}} = \frac{1.5\times10^{-7}\ \mu c/cm^3}{1\times10^{-5}\ \mu c/cm^3}$
Pu^{239}	Bone	$\frac{\rho_{aB}}{(\mathrm{MPC})^{x}_{aB}} = \frac{4\times10^{-13}\ \mu c/cm^3}{2\times10^{-12}\ \mu c/cm^3}$	$\frac{\rho_{wB}}{(\mathrm{MPC})^{x}_{wB}} = \frac{1.3\times10^{-5}\ \mu c/cm^3}{1\times10^{-4}\ \mu c/cm^3}$
	Total body	$\frac{\rho_{aB}}{(\mathrm{MPC})^{T.B.}_{aB}} = \frac{4\times10^{-13}\ \mu c/cm^3}{1\times10^{-11}\ \mu c/cm^3}$	$\frac{\rho_{wB}}{(\mathrm{MPC})^{T.B.}_{wB}} = \frac{1.3\times10^{-5}\ \mu c/cm^3}{1\times10^{-3}\ \mu c/cm^3}$
Na^{24}	Total body	$\frac{\rho_{aC}}{(\mathrm{MPC})^{T.B.}_{aC}} = \frac{2\times10^{-7}\ \mu c/cm^3}{2\times10^{-6}\ \mu c/cm^3}$	$\frac{\rho_{wC}}{(\mathrm{MPC})^{T.B.}_{wC}} = \frac{2\times10^{-3}\ \mu c/cm^3}{1\times10^{-2}\ \mu c/cm^3}$
γ†		Bone $\frac{R^{x}_{\gamma}}{L^{x}} = \frac{0.065\ \text{rem/week}}{0.56\ \text{rem/week}}$	
		Total body $\frac{R^{T.B.}_{\gamma}}{L^{T.B.}} = \frac{0.065\ \text{rem/week}}{0.1\ \text{rem/week}}$	

* The ratios given for Sr^{90}, Pu^{239} and Na^{24} are the ($\mu c/cm^3$ present in air)/$(\mathrm{MPC})^{x}_{aA}$ where $(\mathrm{MPC})^{x}_{aA}$ is the $(\mathrm{MPC})_a$ for element A (Sr^{90}) and organ x (bone), etc.

† The ratio given for γ is the (actual RBE dose rate)/(maximum permissible RBE dose rate).

The concentrations have been chosen to illustrate the case of a mixture which is below the permissible limit for one of the criteria (bone), but is barely in excess of the limit determined by another of the criteria (total body).

Criterion (23) applied to bone gives

$$\frac{\rho_{aA}}{(\mathrm{MPC})^{x}_{aA}} + \frac{\rho_{wA}}{(\mathrm{MPC})^{x}_{wA}} + \frac{\rho_{aB}}{(\mathrm{MPC})^{x}_{aB}} + \frac{\rho_{wB}}{(\mathrm{MPC})^{x}_{wB}} + \frac{0.1}{0.56}\left[\frac{\rho_{aC}}{(\mathrm{MPC})^{TB}_{aC}} + \frac{\rho_{wC}}{(\mathrm{MPC})^{TB}_{wC}}\right] + \frac{R^{*}_{\gamma}}{L^{x}}$$

$$= 0.06 + 0.038 + 0.2 + 0.13 + \frac{0.1}{0.56}(0.1 + 0.2) + \frac{0.065}{0.56} = 0.60 < 1.$$

Thus the average dose rate to the bone is about $0.60 \times 0.56 = 0.34$ effective rem/week and is therefore within the limits set for bone.

Criterion (24) for total body gives

$$\frac{\rho_{aA}}{(\mathrm{MPC})^{T.B.}_{aA}} + \frac{\rho_{wA}}{(\mathrm{MPC})^{T.B.}_{wA}} + \frac{\rho_{aB}}{(\mathrm{MPC})^{T.B.}_{aB}} + \frac{\rho_{wB}}{(\mathrm{MPC})^{T.B.}_{wB}} + \frac{\rho_{aC}}{(\mathrm{MPC})^{T.B.}_{aC}} + \frac{\rho_{wC}}{(\mathrm{MPC})^{T.B.}_{wC}} + \frac{R^{T.B.}_{\gamma}}{L^{T.B.}} =$$

$$0.02 + 0.015 + 0.04 + 0.013 + 0.1 + 0.2 + 0.65 = 1.038$$

and thus the calculation indicates that the mixture is slightly, though not significantly, in excess of the permissible limit for total body.

If the γ-source is removed, the dose rate to the bone becomes $0.48 \times 0.56 = 0.27$ rem/week while the dose rate to the total body is $0.39 \times 0.1 = 0.039$ rem/week. These dose rates are 48 per cent and 39 per cent of the corresponding limits, and thus the bone is now the critical organ. In this situation any or all of the concentrations could be increased by as much as a factor of 2 without exceeding the permissible limits.

9. Modifications required for other applications. The MPC values listed in Table 1 are intended primarily for occupational exposure and for the indicated types of exposure. Nevertheless, they are frequently used for a variety of other purposes. In most cases the conditions of exposure will not strictly conform to the conditions assumed for the calculation of these values. Thus great care and judgment should be used to insure that the departure from the conditions of occupational exposure assumed here are not so great as to completely invalidate the use of these values; some of the more common discrepancies that may often lead to large inaccuracies are mentioned.

A 50 year exposure period is assumed here and the exposure level is assumed to be constant. Thus a transient situation, e.g. fallout shortly after a nuclear detonation or a major reactor accident where the level of activity is rapidly decreasing, and even the

relative abundance of the different radionuclides may be changing, presents a hazard widely different from the constant level 50 year occupational exposure which is assumed. The measure of discrepancy is here so large that to attempt to correct for it amounts to a new calculation.

The $(MPC)_w$ values listed here may be applied to foods, but to use the $(MPC)_w$ for the 168 hr week without correction amounts to assuming that 2200 g of the individual's food, i.e. substantially all his food, is contaminated at this level and that this situation will persist for 50 years, or until equilibrium is reached in the body. Obviously, a correction factor to take account of the intake is needed, but to naïvely use the ratio of 2200 g to the gram intake of a particular food, e.g. butter, per day as correction factor amounts to assuming no other foods or beverages are contaminated. Again, the total situation must be considered and great judgment must be used in making such corrections.

Frequently the MPC values are used to obtain estimates of dose from large single intakes of a radionuclide. In many cases this is warranted, but there may well be many cases where the distribution in the body following an acute exposure to the nuclide is markedly different from the distribution pattern reached following chronic, low-level exposure. For example, many nuclides concentrate in bone with a long biological half-life which leads to a large bone burden of the nuclide after many years of exposure. Then the bone is the critical organ, although the fraction of the daily intake reaching the bone may be much smaller than that passing through the GI tract. For an acute single dose the GI tract may be the critical organ.

Many other factors may have a large effect in determining the proper value for a maximum permissible limit. The relative abundance or scarcity in the diet of other nuclides with similar chemical properties, the wide range of physiological differences as well as differences in habits, age and sex, and the chemical form of the radionuclide or the size of the particle to which it is attached, may account for large changes in the value of the MPC in some cases. Many of these factors as well as others are being carefully studied at the present time, and we may expect that our knowledge of their influence on the permissible levels will be more precise. In the present state of our knowledge, the modification or adaption of the values listed here for application to other situations than those specified by the exposure categories of the basic rules requires the careful consideration and mature judgment of competent experts in this field.

V. FACTORS NEEDED FOR CALCULATION OF MPC EQUATIONS

1. Effective energy. The effective energy term used in the formulas for calculating the values listed in Table 1 takes various forms as needed for the particular problem, i.e. ΣE(RBE), ΣE(RBE)n, ΣEF(RBE)n, and sometimes simply ΣE. In these equations E is the total energy absorbed in the body organ per disintegration of the radionuclide. In these cases, all of the energy absorbed in the tissue in the process of radioactive decay (i.e. X, γ, α, β^-, β^+, e^- and atomic recoils) was included in the effective energy term with exception of the neutrino energy which is assumed to escape from the body. For β-radiation it was assumed that all the energy of each β is dissipated in the critical body organ. Except for very small organs this is justified

since it is generally the maximum dose that is of interest. Various methods have been developed for determining the distribution of β-ray energies and for finding the effective energy, but all are tedious and time consuming and a relatively simple empirical equation that gives results that are in most cases accurate within about 5 per cent was found.[27]

For β^--radiation the equation is

$$E = 0.33\, E_m f \left(1 - \frac{Z^{\frac{1}{2}}}{50}\right) \left(1 + \frac{E_m^{\frac{1}{2}}}{4}\right), \tag{25}$$

in which

Z = atomic number of the radionuclide emitting the β-ray;
f = fraction of the disintegrations of the type considered;
E_m = maximum energy (MeV) of the type considered.

For β^+-radiation the equation is,

$$E = 0.33\, E_m f \left(1 + \frac{E_m^{\frac{1}{2}}}{4}\right) + 2f\,(0.51)\,(1 - e^{-\sigma x}) \tag{26}$$

where

x = effective radius (cm) of the body organ containing the radionuclide (values are given in Table 8);
σ = total coefficient of absorption minus Compton scattering coefficient in cm^{-1} for the given photon energy;

2(0.51) arises from the energy of two 0.51 MeV gammas resulting from the annihilation process.

For other types of radiation, the following equations were used:

For γ-radiation $$E = E_m f\,(1 - e^{-\sigma x}) \tag{27}$$

For α-radiation $$E = E_m f \tag{28}$$

with E_m as the energy of the photon or α-particle.

For internal conversion, e^-

$$E = f\left[(E_\gamma - \eta)\left(\frac{a_K}{1 + a_K}\right) + (\eta)\left(\frac{a_K}{1 + a_K}\right)(1 - e^{-\sigma x}) + E_\gamma\left(\frac{1 - e^{-\sigma x}}{1 + a_K}\right)\right] \tag{29}$$

where

a_K = internal conversion coefficient for the K shell, etc.;
η = binding energy of the daughter element;
E_γ = γ-energy (MeV) of type considered.

For K and L capture X-radiation, the simplification is made that

$$E = f\eta(1 - e^{-\sigma x}) \tag{30}$$

For atomic recoils following α-emission

$$E = f\frac{(\text{energy of } \alpha\text{-particle})\ (\text{mass of } \alpha\text{-particle})}{\text{mass of recoiling daughter nucleus}} \tag{31}$$

RBE = relative biological effectiveness of the radiation; RBE is taken as 1 for β^--, β^+-, γ- and X-radiation and conversion electrons (it is set equal to 1.7 if the maximum energy $E_m \leqslant 0.03$ MeV for β^-, β^+ or e^-), 10 for α-particles, and 20 for recoil atoms;

n = relative damage factor for radionuclides deposited in the bone. The relative damage factor, n, is defined in basic rule (b) and, a detailed discussion of its use, with examples, is given in Section IV.2;

F_i = the ratio at time t of the number of disintegrations per unit time of daughter atoms to the number of disintegrations per unit time of parent atoms in the critical organ. It is a factor that can be multiplied by the energy of the ith daughter so that it may be added to the energy of the other daughters and of the parent in order to obtain the weighted energy of a chain of radionuclides which is equivalent to that absorbed in the critical body organ by a single radionuclide. For the ith daughter,

$$F_i = \frac{\prod_{j=1}^{i} T_j/T_j^r}{1 - e^{-\lambda_0 t}} \sum_{n=0}^{i} \frac{T_n^i\,(1 - e^{-\lambda_n t})}{\prod_{\substack{p=0 \\ p \neq n}}^{i} (T_n - T_p)} \tag{32}$$

in which

λ_0 = total decay coefficient of the parent ($= 0.693/T_0$); the subscript, zero, refers to the parent isotope;

λ_i = total decay coefficient of the ith daughter;

T_i = total half-life of the ith daughter;

T_i^r = radioactive half-life of the ith daughter;

t = occupational exposure time (50 years).

In order to explain the meaning of the notation in the previous equations, equation (32) is expanded. For the parent $F_0 = 1$, for the first daughter

$$F_1 = \frac{T_1/T_1^r}{1 - e^{-\lambda_0 t}}\left[(1 - e^{-\lambda_0 t})\frac{T_0}{T_0 - T_1} + (1 - e^{-\lambda_1 t})\frac{T_1}{T_1 - T_0}\right] \tag{33}$$

and for the second daughter,

$$F_2 = \frac{T_1\,T_2/T_1^r\,T_2^r}{1 - e^{-\lambda_0 t}}\left[\frac{(1 - e^{-\lambda_0 t})\,T_0^2}{(T_0 - T_1)\,(T_0 - T_2)} + \frac{(1 - e^{-\lambda_1 t})\,T_1^2}{(T_1 - T_0)\,(T_1 - T_2)} + \frac{(1 - e^{-\lambda_2 t})\,T_2^2}{(T_2 - T_0)\,(T_2 - T_1)}\right] \tag{34}$$

etc., for all daughters of the chain. The appearance of these factors in the MPC equations is discussed in Section IV.4. In the case of radium isotopes which are daughters of a thorium isotope, recent experimental work has indicated that the radium daughter behaves as though it is absorbed into the blood. In these cases the factor f_2' for radium was included in the formula for F_1, F_2, etc.

The effective energy can be found by simply summing the component terms of $\Sigma\, EF(\mathrm{RBE})n$,

$$\Sigma\, EF(\mathrm{RBE})n = \Sigma_i F_i \left[(\mathrm{RBE})_j f_j^i E_j^i + (\mathrm{RBE})_k f_k^i E_k^i n_k^i + (\mathrm{RBE})_s f_s^i E_s^i n_s^i + \right. \tag{35}$$

$$\left. (\mathrm{RBE})_m f_m^i E_m^i n_m^i + (\mathrm{RBE})_v f_v^i E_v^i n_v^i + (\mathrm{RBE})_p f_p^i E_p^i + (\mathrm{RBE})_r f_r^i E_r^i n_r^i \right]$$

where the subscripts j, k, s, m, v, p and r refer to γ, negatron, positron, α, internal conversion, electron capture, and α-recoil, respectively. The RBE of these radiations is specified above.

Effective energies[28] used for making the permissible exposure calculations of Table 1 are given in Tables 5 and 5(a). In Table 5(a) all the daughter nuclides are listed individually following the parent nuclide. The detailed listing is necessary here because the formulas for the GI tract require individual energies for each daughter nuclide. Also, the F_i factors necessitate separate listings for the entire chain, so that with the complete data as given, values for MPC and body burden for any mixture of parent and daughter radionuclides can be calculated easily.

2. Standard man data. In order that all MPC values be calculated on a common biological basis the so-called "standard man" or "average man" was defined.[29, 30] The first committee values were stipulated at the Chalk River Conference,[9] but later modified at the Sixth International Congress of Radiology,[31] the Harriman Conference on Permissible Dose,[32] and the Seventh International Congress of Radiology.[33] The values for the GI tract[34] (Table 11) and the chemical composition of the individual organs (Table 7) are further additions to the standard man. In Table 12 a few references have been listed, but it must be emphasized that these are only a few of those which were consulted. For a detailed study the reader should consult the references cited in *Bibliography for Biological Data** and the references listed below.[35–39]

3. Other biological and related physical terms. Other relevant biological and related physical terms that were used in the preparation of Table 1 appear in Table 12. For each element and radionuclide, the many distribution fractions, the concentration in the critical organs, the biological half-lives, etc., were gleaned from a voluminous amount of experimental data: data which, though great in mass, yielded in many cases a sparse amount of information concerning the specific quantities needed. Ideally, to establish satisfactory MPC values for occupational exposure, data are needed of lifetime exposure of humans to each of the radionuclides. However, not only are such data almost non-existent for man (see Section III for detailed

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discussion) but they are extremely scarce for animals. As stated earlier, many of the biological factors used for the continuous exposure calculations of Table 1 were not obtained directly from continuous exposure animal data but of necessity were taken from single exposure data. Exploratory experiments[40] have indicated that extrapolation from single dose studies to the situation corresponding to continuous exposure is fairly satisfactory, if the single exposure data of retention in the critical body organ yield a curve having a long straight portion when plotted as a function of time on semilogarithmic paper. In general, the radionuclide does not seem to be uniformly bound in an organ and the retention curve is represented as a sum of exponentials. The component of longest half-life is generally the most significant for the long-term exposure case, and this is obtained by extrapolating back to time $t = 0$ the straight portion mentioned above. It sometimes happens that no data—not even data from single exposure of animals—are available for an element. When this is the case, it may be possible to obtain some of the desired information by assuming the existence of an equilibrium condition between the stable isotopes of the element in the critical body organ and in the food, water and air taken into the body from the environment,[10] i.e. set the amount ingested and deposited in the critical organ per day equal to the amount eliminated from it per day. For other cases where experimental data are not found, direct comparisons sometimes are made with elements that are chemically similar. Many equations and approximations—some of which are listed in this section—were used to check and cross-check the values given in these tables.

(a) I = average daily ingestion of an element (g/day).
(b) f_1 = fraction of the radionuclide passing from GI tract to blood.
(c) C = average concentration of the element in the critical organ (grams of element per gram of wet tissue).
(d) f_2' = fraction of the radionuclide passing from blood to critical body organ; in some cases this is chosen to represent only the component of longest biological half-life as mentioned above.
(e) f_2 = fraction of the radionuclide in the critical organ of that in total body. This fraction is required in the calculation of the maximum permissible body burden, q. The fraction f_2 is unusually difficult to find from limited experimental data, so it is fortunate that f_2 is not required for the calculation of MPC values. Various methods employing more easily measured fractions are often utilized for arriving at f_2; they are enumerated as follows:
  (i) Under conditions of continuous exposure where equilibrium has been reached

$$f_2^x = \frac{q^x}{q^x+q^y+q^z+\ \ldots} = \frac{q^x}{q} \tag{36}$$

in which the superscripts x, y, z, etc., refer to different body organs, e.g. $q^x = \mu c$ in organ x, $q^y = \mu c$ in organ y, etc., and $q = \mu c$ in total body.

(ii) In cases where f_w and T can be found from single exposure data, f_2 can be determined by

$$f_2^x = \frac{T^x f_w^x}{T^x f_w^x + T^y f_w^y + T^z f_w^z + \ldots} \tag{37}$$

Sometimes when a long time has elapsed since the radionuclide was administered as a single exposure the biological half-lives for the various organs become approximately equal. In such cases

$$f_2^x = \frac{f_w^x}{f_w^x + f_w^y + f_w^z + \ldots} \tag{38}$$

(iii) For intravenous single exposure data equation (38) can be used by setting $f_w^x = f_1 f_2'^x, f_w^y = f_1 f_2'^y$ etc. Then,

$$f_2^x = \frac{f_2'^x}{f_2'^x + f_2'^y + f_2'^z + \ldots} \tag{39}$$

Equations (38) and (39) also apply in all cases where $T_r \ll T_b$ for organs x, y, z, etc.

(iv) For single exposure data

$$f_2^x = \frac{T^x f_w^x}{T^t(f_1 - f_w^u)} = \frac{T^x f_w^x}{T^t(f_w^x + f_w^y + f_w^z + \ldots)} = \frac{T^x f_2'^x}{T^t(f_2'^x + f_2'^y + f_2'^z \ldots)} \tag{40}$$

in which the superscript, t, refers to total body and f_w^u = fraction of that ingested that goes rapidly to the urine. Where data are not available for f_w^u, the following approximations may be used;

$$f_2^x \geqslant \frac{T^x f_w^x}{T^t f_1} \tag{41}$$

$$f_2^x \geqslant \frac{T^x f_a^x}{T^t f_a^t} \tag{42}$$

(v) In the case of stable isotopes or radionuclides, where $T_r \gg T_b$,

$$f_2^x = \frac{m^x C^x}{m^t C^t}$$

Equations (37), (41) and (42) can be modified for this case so that

$$f_2^x = \frac{T_b^x f_w^x}{T_b^x f_w^x + T_b^y f_w^y + T_b^z f_w^z \ldots} \tag{43}$$

and

$$f_2^x = \frac{T_b^x f_w^x}{T_b^i f_1} \tag{44}$$

$$f_2^x = \frac{T_b^x f_a^x}{T_b^i f_a^i} \tag{45}$$

(f) f_a = fraction of that taken into the body by inhalation that arrives in the critical organ. For soluble material

$$f_a = (0.25 + 0.5 f_1) f_2' \tag{46}$$

When the fraction f_2', is unknown, it is replaced by f_2. It is sometimes convenient to write f_a in the form $f_a = (0.5 + 0.25/f_1) f_w$. MPC values are given in Table 1 for inhalation of insoluble and slightly soluble materials and in these cases a portion of the GI tract or the lung is usually the critical organ. Unless data are available for the inhalation of specific radioactive, insoluble dust particles, it is assumed in the case of the lungs that $f_a = 0.12$. Some of the inhaled radioactive material is swallowed, so that it irradiates the GI tract. In the case in which a portion of the GI tract is the critical tissue, the value of f_a is given by the equation, $f_a = 0.62$ for insoluble material and $f_a = 0.5$ for soluble.

(g) f_w = fraction of that taken into the body by ingestion that is retained in the critical organ. For ingestion of soluble compounds

$$f_w = f_1 f_2' \tag{47}$$

f_2 is sometimes used instead of f_2' if no better information is available. For ingestion of insoluble compounds a portion of the GI tract is the critical tissue.

(h) T_b = biological half-life or the time required for half of the element or radionuclide to be eliminated by biological processes. When T_b cannot be found from experimental data for a particular radionuclide, the assumption is made that the radionuclide has the same biological elimination time as the stable element. Assuming the existence of an equilibrium condition between the stable element in the food and water and the stable element in the critical body organ, the grams eliminated per day may be set equal to the grams deposited per day. It follows then that for a stable element

$$T_b = \frac{0.693\, m\, C}{I f_w} \tag{48}$$

In the above equation f_w may be replaced by f_a if inhalation rather than ingestion is responsible for the deposition of the stable element in the body. For insoluble material in the lungs, T_b is taken as 120 days for all radionuclides except plutonium and thorium, in which case $T_b =$ 1 year and $T_b = 4$ years, respectively, were used.

(i) $T_r =$ radioactive half-life.

(j) $T =$ effective half-life. Because by definition the total decay coefficient is equal to the sum of the biological and physical decay coefficients, i.e. $\lambda = \lambda_r + \lambda_b$,

$$T = \frac{T_b\, T_r}{T_b + T_r} \tag{49}$$

For a radionuclide equation (48) becomes

$$T = \frac{0.693\, m\, C}{I f_w} \tag{50}$$

in which $C =$ grams of radionuclide per gram of organ. If $T_r \gg T_b$, C for the stable element is approximately equal to C for the radioelement.

As explained previously, single exposure data can be used satisfactorily to find biological constants for chronic exposure if the retention data plotted on a semi-logarithmic graph as a function of time of exposure yield a curve with a long straight portion following the initial rapid elimination. If the data are not corrected for radioactive decay, the effective half-life in such cases is related to the ordinate b of the curve, taken at the beginning of the straight portion and ordinate c taken at some later time by the expression

$$T = \frac{0.693\, t}{\ln b/c} \tag{51}$$

in which $t =$ time interval between b and c

In any two organs x and y,

$$\frac{f_{\frac{1}{2}}^x}{f_{\frac{1}{2}}^y} = \frac{m^x\, C^x}{m^y\, C^y} \tag{52}$$

and,

$$\frac{T^x}{T^y} = \frac{f_{\frac{1}{2}}^x f_w^x}{f_{\frac{1}{2}}^y f_w^y} \tag{53}$$

As indicated earlier, the critical body organ is that organ receiving the radionuclide that results in the greatest body damage. However, in most cases it is the body

organ that accumulates the greatest concentration of the radionuclide. Having selected the critical body organ, it is useful to make a check to determine whether or not this organ has an above average concentration. If the concentration in organ x is greater than the average concentration in the rest of the body

$$\frac{m(1-f_2^x)}{(70{,}000-m)f_2^x} \leqslant 1 \tag{54}$$

APPENDIX

Concentrations in air and in water based on a power function model. Although the formulas used to calculate the maximum permissible concentrations assume that the biological elimination follows a simple exponential function, i.e. the fraction of organ burden eliminated per day is constant, cognizance is taken of the fact that many data[41] support the view that the fraction of the body burden excreted per day varies inversely with the time and could best be represented by a power function. Following a single injection of certain bone-seeking radionuclides, the body burden has been expressed by

$$R(t) = A\,t^{-n} \qquad t \geqq 1 \tag{55}$$

where $R(t)$ = fractional retention t days after injection;
A = normalized fraction of injected dose retained at end of unit time;
n = a constant.

Ingested or inhaled material may not be retained to the same degree, therefore a factor, f_1, should be included to designate the fraction of ingested radionuclide which reaches the blood stream. If the radionuclide is long-lived so that radioactive decay can be neglected, then the body burden after an amount, a, has been ingested per day for T days is given by

$$q = A\,a f_1 \int_0^T (T-\tau)^{-n}\,d\tau = \frac{A\,a f_1}{1-n}\,T^{1-n}\,\mu c \tag{56}$$

This equation assumes n is not close to 1. Otherwise the integration should extend from 1 day to T days and the contribution of the first day added. In terms of the previous notation $a = P/f_w = 750\ \mathrm{M} = 750\ (\mathrm{MPC})_w$ for ingestion or $a = P/f_a = 6.9 \times 10^6\ (\mathrm{MPC})_a$ for inhalation, and T is the period of occupational exposure which is set at 50 years for the values recorded in Table 1.

If the radioactive half-life of the radionuclide is of the same order as T, it may be taken into account also. If the body burden following a single intravenous injection, $R(t)$, is a power function, the fraction eliminated per day is given by

$$\frac{dR}{dt}/R = -\frac{n}{t} \tag{57}$$

which represents only the biological elimination of the radionuclide because experiments determining the best values for A and n are generally of short duration as compared to the radioactive half-life of the radionuclides here considered (Sr, Ra, Pu and U); thus, including radioactive decay

$$dR/dt = -\frac{n}{t} R(t) - \lambda^r R(t) \tag{58}$$

where λ^r is the radioactive decay constant of the radionuclide in days.

The integral of this equation with $R(1) = A$ readily is found to be

$$R(t) = A\, t^{-n}\, e^{-\lambda^r (t-1)} \quad t > 1 \tag{59}$$

Hence, if the radionuclide is undergoing appreciable radioactive decay while it is being eliminated from the body according to a power function, the body burden under the same conditions as before is given by

$$q = a\, A f_1 \int_0^T (T - \tau)^{-n}\, e^{-\lambda^r (T-\tau-1)} = a\, A f_1 \int_0^T u^{-n}\, e^{-\lambda^r (u-1)}\, du\ \mu c \tag{60}$$

or

$$(MPC)_a = \frac{q}{6.9 \times 10^6\, A f_1 \int_0^T u^{-n}\, e^{-\lambda^r (u-1)}\, du}\ \mu c/cm^3 \tag{61}$$

and

$$(MPC)_w = \frac{q}{750\, A f_1 \int_0^T u^{-n}\, e^{-\lambda^r (u-1)}\, du}\ \mu c/cm^3 \tag{62}$$

This integral may be evaluated with the help of a table of the incomplete γ-function.[42]

In case the radionuclide has daughters which must be taken into account, the power function estimate of elimination still may be applied. In principle, the daughter elements might be eliminated at rates quite different from those of the parent, i.e. the constant n may be different for different elements of the chain. In such cases the value of n would vary from element to element in the chain. The formulas for this case would be similar to those given above.

For example, in the case of Ra^{228} it seems desirable to consider the elements of a chain. Because all these elements are held very tenaciously in the body, the daughter elements with radioactive half-lives of a few hours or days may be considered to decay immediately and thus only the case of a chain of two radionuclides is discussed. Also the same value of n is assumed for each of these radionuclides.

Letting $R_0(t)$ and $R_1(t)$ denote the body burden (μc) of the parent and the daughter radionuclide, respectively, at time t days following injection of 1 μc of the parent, the differential equations governing the changes with time are:

$$\frac{dR_0}{dt} = \frac{-n}{t} R_0(t) - \lambda_0^r R_0(t) \tag{63}$$

$$\frac{dR_1}{dt} = \frac{-n}{t} R_1(t) - \lambda_1^r R_1(t) + \lambda_1^r R_0(t) \tag{64}$$

The solution which gives an amount A for the parent and 0 for the daughters at $t = 1$ is given by,

$$R_0(t) = A\, t^{-n}\, e^{-\lambda_0^r (t-1)} \tag{65}$$

$$R_1(t) = \frac{A\, \lambda_1^r\, t^{-n}}{\lambda_1^r - \lambda_0^r}\left[e^{-\lambda_0^r (t-1)} - e^{-\lambda_1^r (t-1)}\right] \tag{66}$$

Except for the presence of the factor $A\, t^{-n}$ these equations are identical with the expanded form of equation (9). This solution is valid only if $n\ 1 \ll$ but this is true in all the practical cases considered here. The choice of the solution where $R_0(1) = A$ and $R_1(1) = 0$ neglects the formation of the daughter radionuclides during the first day. Because it is only applied here to radionuclides of rather long radioactive half-life, and because the power function does not represent adequately the behavior of the radionuclide for short periods of time after injection, this neglect seems justified.

If an amount, a μc, enters the blood per day during a period of T days, the body burden of the ith isotope at the end of T days is given by

$$a \int_0^T R_i(T - t)\, dt \tag{67}$$

and this leads to an incomplete γ-function which may be evaluated as before. From these estimates of body burden, the $(\mathrm{MPC})_a$ and $(\mathrm{MPC})_w$ can be estimated by the method used in deriving equations (61) and (62).

At present the use of a power function is possible in only a few cases. There is some indication that it does not represent precisely the true situation since the exponent n has been found to vary with time.[43] However, for the radionuclides with long physical half-lives, the power function does seem to represent adequately the available long-term data. Unfortunately, its metabolic significance remains unexplained, and it does not seem desirable to extrapolate an empirical formula far beyond the range where it has been verified experimentally. For comparison, MPC values have been computed both according to the exponential model and the power law for the radionuclides of Sr, Ra, Pu and U which have an effective half-life exceeding 20 days. In these cases, the Committee has considered the MPC values obtained both by the power function as well as by the exponential method in

selecting the values listed in Table 1. The values of the constants considered and the MPC values obtained in the case of the more important isotopes of these four elements are listed in Table *B*. These values were selected by a Subcommittee on the Power Function.*

Table B. MPC values as calculated by the power function model
(168 hr/week)

Radionuclides and retention constants	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	Critical organ
Strontium			
$A = 0.65$, $n = 0.35$			
Sr^{85}	6×10^{-3}	5×10^{-7}	Bone
Sr^{89}	4×10^{-4}	4×10^{-8}	Bone
Sr^{90}	8×10^{-6}	7×10^{-10}	Bone
Strontium			
$A = 0.95$, $n = 0.25$			
Sr^{85}	3×10^{-3}	2×10^{-7}	Bone
Sr^{89}	2×10^{-4}	2×10^{-8}	Bone
Sr^{90}	6×10^{-6}	5×10^{-10}	Bone
Radium			
$A = 0.54$, $n = 0.52$			
Ra^{226}	1×10^{-6}	1×10^{-10}	Bone
Ra^{228}	2×10^{-6}	1×10^{-10}	Bone
Uranium			
$A = 0.72$, $n = 0.80$			
U^{238}	8×10^{-4}	4×10^{-11}	Kidney
U–nat	8×10^{-4}	4×10^{-11}	Kidney
Plutonium			
$A = 0.99$, $n = 0.01$			
Pu^{238}	5×10^{-5}	6×10^{-13}	Bone
Pu^{239}	4×10^{-5}	5×10^{-13}	Bone
Pu^{240}	4×10^{-5}	5×10^{-13}	Bone
Pu^{241}	2×10^{-3}	3×10^{-11}	Bone
Pu^{242}	5×10^{-5}	6×10^{-13}	Bone

In the cases considered, the power function method seems to yield a higher estimate of the MPC values than does the exponential method. Since, in principle, the retention data can be fitted with a multiple exponential curve, this undoubtedly is in large part due to conservatism in assigning a long biological half-life and a rather large value to the fraction of material in the blood that has the long half-life, i.e. to f_2'. While the MPC values listed in the accompanying table were considered by the

* The data in Table *B* were developed and agreed upon by a special subcommittee which was organized to evaluate the application of the power function in obtaining MPC values. The members were: W. H. LANGHAM, Chairman, E. C. ANDERSON, P. HARRIS, J. W. HEALY, W. P. NORRIS and W. S. SNYDER.

Committee in making their final decision, they are not to be considered as recommended values. They are listed to indicate that the Committee has considered carefully this method of estimation and to stimulate research concerning the interpretation and validity of this model. The presentation of the biological data in Table 12 on the basis of the exponential model is in large part dictated by the desire to give a unified and economical presentation of the material.

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18. See references Br–44 and No–7.
19. See reference Ea–5.
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Table 1. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure

Radionuclide and type of decay	Organ of reference* (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hr week		For 168 hr week	
			$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
$_1H^3$(HTO or H_2^3O) β^- [(sol.)	**Body tissue**	10^3	**0.1**	**5×10^{-6}**	**0.03**	**2×10^{-6}**
	Total body	2×10^3	0.2	8×10^{-6}	0.05	3×10^{-6}
(H_2^3) (submersion)	**Skin**			**2×10^{-3}**		**4×10^{-4}**
$_4Be^7$ (sol.) ϵ, γ	**GI (LLI)**		**0.05**	10^{-5}	**0.02**	4×10^{-6}
	Total body	600	6	**6×10^{-6}**	2	**2×10^{-6}**
	Kidney	800	9	8×10^{-6}	3	3×10^{-6}
	Liver	800	9	8×10^{-6}	3	3×10^{-6}
	Bone	2×10^3	20	2×10^{-5}	7	6×10^{-6}
	Spleen	4×10^3	50	4×10^{-5}	20	2×10^{-5}
(insol.)	**Lung**			**10^{-6}**		**4×10^{-7}**
	GI (LLI)		**0.05**	9×10^{-6}	**0.02**	3×10^{-6}
$_6C^{14}(CO_2)$ (sol.) β^-	**Fat**	300	**0.02**	**4×10^{-6}**	**8×10^{-3}**	**10^{-6}**
	Total body	400	0.03	5×10^{-6}	0.01	2×10^{-6}
	Bone	400	0.04	6×10^{-6}	0.01	2×10^{-6}
(submersion)	**Total body**			**5×10^{-5}**		**10^{-5}**
$_9F^{18}$ (sol.) β^+	**GI (SI)**		**0.02**	**5×10^{-6}**	**8×10^{-3}**	**2×10^{-6}**
	Bone and teeth	20	0.2	3×10^{-5}	0.06	9×10^{-6}
	Total body	20	0.3	4×10^{-5}	0.09	10^{-5}
(insol.)	**GI (ULI)**		**0.01**	**3×10^{-6}**	**5×10^{-3}**	**9×10^{-7}**
	Lung			2×10^{-5}		6×10^{-6}
$_{11}Na^{22}$ (sol.) β^+, γ	**Total body**	10	**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**6×10^{-3}**
	GI (LLI)		0.01	2×10^{-6}	3×10^{-3}	7×10^{-7}
(insol.)	**Lung**			**9×10^{-9}**		**3×10^{-9}**
	GI (LLI)		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
$_{11}Na^{24}$ (sol.) β^-, γ	**GI (SI)**		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
	Total body	7	0.01	2×10^{-6}	4×10^{-3}	6×10^{-7}
(insol.)	**GI (LLI)**		**8×10^{-4}**	**10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
	Lung			8×10^{-7}		3×10^{-7}

* The abbreviations GI, S, SI, ULI and LLI refer to gastrointestinal tract, stomach, small intestine, upper large intestine, and lower large intestine, respectively.

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
$_{14}Si^{31}$ β^-, γ	(sol.)	**GI (S)**		**0.03**	**6×10^{-6}**	**9×10^{-3}**	**2×10^{-6}**
		Lung	10	0.1	2×10^{-5}	0.05	7×10^{-6}
		Adrenal	30	0.3	4×10^{-5}	0.1	10^{-5}
		Total body	30	0.3	4×10^{-5}	0.1	2×10^{-5}
		Testis	40	0.4	5×10^{-5}	0.1	2×10^{-5}
		Ovary	60	0.6	8×10^{-5}	0.2	3×10^{-5}
		Skin	100	1	2×10^{-4}	0.5	7×10^{-5}
	(insol.)	**GI (ULI)**		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**3×10^{-7}**
		Lung			10^{-5}		4×10^{-6}
$_{15}P^{32}$ β^-	(sol.)	**Bone**	6	**5×10^{-4}**	**7×10^{-8}**	**2×10^{-4}**	**2×10^{-8}**
		Total body	30	3×10^{-3}	4×10^{-7}	9×10^{-4}	10^{-7}
		GI (LLI)		3×10^{-3}	6×10^{-7}	9×10^{-4}	2×10^{-7}
		Liver	50	5×10^{-3}	6×10^{-7}	2×10^{-3}	2×10^{-7}
		Brain	300	0.02	3×10^{-6}	8×10^{-3}	10^{-6}
	(insol.)	**Lung**			**8×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**7×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
$_{16}S^{35}$ β^-	(sol.)	**Testis**	90	**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**9×10^{-8}**
		Total body	400	7×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		Bone	800	0.02	2×10^{-6}	5×10^{-3}	8×10^{-7}
		Skin	3×10^3	0.07	10^{-5}	0.02	3×10^{-6}
		GI (LLI)		0.2	4×10^{-5}	0.05	10^{-5}
	(insol.)	**Lung**			**3×10^{-7}**		**9×10^{-8}**
		GI (LLI)		**8×10^{-3}**	10^{-6}	**3×10^{-3}**	5×10^{-7}
$_{17}Cl^{36}$ β^-	(sol.)	**Total body**	80	**2×10^{-3}**	**4×10^{-7}**	**8×10^{-4}**	**10^{-7}**
		GI (LLI)		0.04	8×10^{-6}	0.01	3×10^{-6}
	(insol.)	**Lung**			**2×10^{-8}**		**8×10^{-9}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}
$_{17}Cl^{38}$ β^-, γ	(sol.)	**GI (S)**		**0.01**	**3×10^{-6}**	**4×10^{-3}**	**9×10^{-7}**
		Total body	9	0.3	4×10^{-5}	0.1	2×10^{-5}
	(insol.)	**GI (S)**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**7×10^{-7}**
		Lung			10^{-5}		5×10^{-6}
$_{18}A^{37}$ ϵ	(submersion)	**Skin**			**6×10^{-3}**		**10^{-3}**
$_{18}A^{41}$ β^-, γ	(submersion)	**Total body**			**2×10^{-6}**		**4×10^{-7}**

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{19}K^{42}$ β^-, γ	(sol.)	**GI (S)**		**9×10^{-3}**	**2×10^{-6}**	**3×10^{-3}**	**7×10^{-7}**
		Total body	10	0.02	3×10^{-6}	8×10^{-3}	10^{-6}
		Brain	20	0.04	6×10^{-6}	0.01	2×10^{-6}
		Spleen	20	0.04	6×10^{-6}	0.01	2×10^{-6}
		Muscle	20	0.04	6×10^{-6}	0.02	2×10^{-6}
		Liver	50	0.08	10^{-5}	0.03	4×10^{-6}
	(insol.)	**GI (LLI)**		**6×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Lung			9×10^{-7}		3×10^{-7}
$_{20}Ca^{45}$ β^-	(sol.)	**Bone**	**30**	**3×10^{-4}**	**3×10^{-8}**	**9×10^{-5}**	**10^{-8}**
		Total body	200	2×10^{-3}	3×10^{-7}	7×10^{-4}	9×10^{-8}
		GI (LLI)		0.01	3×10^{-6}	4×10^{-3}	10^{-6}
	(insol.)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**5×10^{-3}**	**9×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
$_{20}Ca^{47}$ β^-, γ	(sol.)	**Bone**	5	**10^{-3}**	**2×10^{-7}**	**5×10^{-4}**	**6×10^{-8}**
		GI (LLI)		2×10^{-3}	5×10^{-7}	8×10^{-4}	2×10^{-7}
		Total body	10	4×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
		Lung			**2×10^{-7}**		**6×10^{-8}**
$_{21}Sc^{46}$ β^-, γ	(sol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**8×10^{-8}**
		Liver	**10**	6	**2×10^{-7}**	2	**8×10^{-8}**
		Kidney	10	6	3×10^{-7}	2	9×10^{-8}
		Total body	20	6	3×10^{-7}	2	10^{-7}
		Bone	60	20	10^{-6}	8	4×10^{-7}
	(insol.)	**Lung**			**2×10^{-8}**		**8×10^{-9}**
		GI (LLI)		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**7×10^{-8}**
$_{21}Sc^{47}$ β^-, γ	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
		Liver	50	100	6×10^{-6}	50	2×10^{-6}
		Kidney	60	200	8×10^{-6}	60	3×10^{-6}
		Bone	60	200	8×10^{-6}	60	3×10^{-6}
		Total body	80	200	10^{-5}	80	3×10^{-6}
	(insol.)	**GI (LLI)**		**3×10^{-3}**	**5×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
		Lung			10^{-6}		3×10^{-7}
$_{21}Sc^{48}$ β^-, γ	(sol.)	**GI (LLI)**		**8×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
		Total body	9	50	2×10^{-6}	20	7×10^{-7}
		Liver	9	50	2×10^{-6}	20	7×10^{-7}
		Kidney	10	80	3×10^{-6}	30	10^{-6}
		Bone	30	200	8×10^{-6}	60	3×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**GI (LLI)**		**8×10^{-4}**	**10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
		Lung			4×10^{-7}		10^{-7}
$_{23}V^{48}$	(sol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
β^-, ϵ, γ		Kidney	8	0.03	3×10^{-7}	0.01	9×10^{-8}
		Total body	10	0.04	4×10^{-7}	0.02	10^{-7}
		Spleen	20	0.06	5×10^{-7}	0.02	2×10^{-7}
		Liver	20	0.09	8×10^{-7}	0.03	3×10^{-7}
		Bone	60	0.2	2×10^{-6}	0.08	7×10^{-7}
	(insol.)	**Lung**			**6×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{24}Cr^{51}$	(sol.)	**GI (LLI)**		**0.05**	**10^{-5}**	**0.02**	**4×10^{-6}**
ϵ, γ		**Total body**	800	0.6	**10^{-5}**	0.2	**4×10^{-6}**
		Lung	10^3	1	2×10^{-5}	0.4	8×10^{-6}
		Prostate	2×10^3	2	3×10^{-5}	0.5	10^{-5}
		Thyroid	4×10^3	3	6×10^{-5}	1	2×10^{-5}
		Kidney	8×10^3	6	10^{-4}	2	4×10^{-5}
	(insol.)	**Lung**			**2×10^{-6}**		**8×10^{-7}**
		GI (LLI)		**0.05**	8×10^{-6}	**0.02**	3×10^{-6}
$_{25}Mn^{52}$	(sol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
β^+, ϵ, γ		Pancreas	5	0.01	4×10^{-7}	4×10^{-3}	2×10^{-7}
		Liver	6	0.01	5×10^{-7}	4×10^{-3}	2×10^{-7}
		Total body	9	0.02	8×10^{-7}	7×10^{-3}	3×10^{-7}
	(insol.)	**Lung**			**10^{-7}**		**5×10^{-8}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	**5×10^{-8}**
$_{25}Mn^{54}$	(sol.)	**GI (LLI)**		**4×10^{-3}**	8×10^{-7}	**10^{-3}**	3×10^{-7}
ϵ, γ		**Liver**	20	0.01	**4×10^{-7}**	4×10^{-3}	**10^{-7}**
		Total body	40	0.02	8×10^{-7}	8×10^{-3}	3×10^{-7}
		Pancreas	50	0.02	9×10^{-7}	9×10^{-3}	3×10^{-7}
	(insol.)	**Lung**			**4×10^{-8}**		**10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}
$_{25}Mn^{56}$	(sol.)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
β^-, γ		Pancreas	2	0.2	6×10^{-6}	0.05	2×10^{-6}
		Liver	5	0.4	10^{-5}	0.1	5×10^{-6}
		Total body	10	0.9	3×10^{-5}	0.3	10^{-5}
	(insol.)	**GI (LLI)**		**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			5×10^{-6}		2×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{26}Fe^{55}$ ϵ	(sol.)	**Spleen**	10^3	**0.02**	**9×10^{-7}**	**8×10^{-3}**	**3×10^{-7}**
		Liver	2×10^3	0.04	2×10^{-6}	0.01	5×10^{-7}
		Total body	3×10^3	0.06	2×10^{-6}	0.02	8×10^{-7}
		Lung	4×10^3	0.07	3×10^{-6}	0.03	9×10^{-7}
		GI (LLI)		0.08	2×10^{-5}	0.03	6×10^{-6}
		Bone	7×10^3	0.1	5×10^{-6}	0.04	2×10^{-6}
	(insol.)	**Lung**			**10^{-6}**		**3×10^{-7}**
		GI (LLI)		**0.07**	**10^{-5}**	**0.02**	**4×10^{-6}**
$_{26}Fe^{59}$ β^-, γ	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Spleen	20	**4×10^{-3}**	**10^{-7}**	**10^{-3}**	**5×10^{-8}**
		Total body	20	5×10^{-3}	2×10^{-7}	2×10^{-3}	7×10^{-8}
		Liver	30	6×10^{-3}	2×10^{-7}	2×10^{-3}	7×10^{-8}
		Lung	100	0.02	8×10^{-7}	7×10^{-3}	3×10^{-7}
		Bone	100	0.03	10^{-6}	0.01	4×10^{-7}
	(insol.)	**Lung**			**5×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**5×10^{-4}**	**9×10^{-8}**
$_{27}Co^{57}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**0.02**	**3×10^{-6}**	**5×10^{-3}**	**10^{-6}**
		Total body	200	0.07	6×10^{-6}	0.03	2×10^{-6}
		Pancreas	700	0.2	2×10^{-5}	0.08	7×10^{-6}
		Liver	10^3	0.4	2×10^{-5}	0.1	6×10^{-6}
		Spleen	2×10^3	0.7	6×10^{-5}	0.2	2×10^{-5}
		Kidney	3×10^3	0.9	8×10^{-5}	0.3	3×10^{-5}
	(insol.)	**Lung**			**2×10^{-7}**		**6×10^{-8}**
		GI (LLI)		**0.01**	2×10^{-6}	**4×10^{-3}**	7×10^{-7}
$_{27}Co^{58m}$ $\beta^+, \epsilon, \gamma$	(sol.)	**GI (LLI)**		**0.08**	**2×10^{-5}**	**0.03**	**6×10^{-6}**
		Total body	200	2	10^{-4}	0.6	5×10^{-5}
		Pancreas	800	6	5×10^{-4}	2	2×10^{-4}
		Liver	10^3	9	4×10^{-4}	3	10^{-4}
		Spleen	2×10^3	20	10^{-3}	5	4×10^{-4}
		Kidney	3×10^3	20	2×10^{-3}	8	6×10^{-4}
	(insol.)	**Lung**			**9×10^{-6}**		**3×10^{-6}**
		GI (LLI)		**0.06**	10^{-5}	**0.02**	4×10^{-6}
$_{27}Co^{58}$ β^+, ϵ	(sol.)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Total body	30	0.01	**10^{-6}**	4×10^{-3}	**3×10^{-7}**
		Pancreas	200	0.06	5×10^{-6}	0.02	2×10^{-6}
		Liver	200	0.08	4×10^{-6}	0.03	10^{-6}
		Spleen	400	0.1	10^{-5}	0.05	4×10^{-6}
		Kidney	600	0.2	2×10^{-5}	0.07	6×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**Lung**			**5×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**9×10^{-4}**	2×10^{-7}
$_{27}Co^{60}$ β^-, γ	(sol.)	**GI (LLI)**		**10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**10^{-7}**
		Total body	10	4×10^{-3}	4×10^{-7}	10^{-3}	10^{-7}
		Pancreas	70	0.02	2×10^{-6}	7×10^{-3}	6×10^{-7}
		Liver	90	0.03	10^{-6}	9×10^{-3}	5×10^{-7}
		Spleen	200	0.05	4×10^{-6}	0.02	2×10^{-6}
		Kidney	200	0.07	6×10^{-6}	0.03	2×10^{-6}
	(insol.)	**Lung**			**9×10^{-9}**		**3×10^{-9}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
$_{28}Ni^{59}$ ϵ	(sol.)	**Bone**	10^3	**6×10^{-3}**	**5×10^{-7}**	**2×10^{-3}**	**2×10^{-7}**
		Total body	3×10^3	0.01	10^{-6}	4×10^{-3}	3×10^{-7}
		Liver	4×10^3	0.02	10^{-6}	6×10^{-3}	5×10^{-7}
		GI (LLI)		0.08	2×10^{-5}	0.03	6×10^{-6}
	(insol.)	**Lung**			**8×10^{-7}**		**3×10^{-7}**
		GI (LLI)		**0.06**	10^{-5}	**0.02**	3×10^{-6}
$_{28}Ni^{63}$ β^-	(sol.)	**Bone**	200	**8×10^{-4}**	**6×10^{-8}**	**3×10^{-4}**	**2×10^{-8}**
		Total body	900	4×10^{-3}	4×10^{-7}	2×10^{-3}	10^{-7}
		Liver	10^3	6×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
		GI (LLI)		0.03	6×10^{-6}	0.01	2×10^{-6}
	(insol.)	**Lung**			**3×10^{-7}**		**10^{-7}**
		GI (LLI)		**0.02**	4×10^{-6}	**7×10^{-3}**	10^{-6}
$_{28}Ni^{65}$ β^-, γ	(sol.)	**GI (ULI)**		**4×10^{-3}**	**9×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Bone	4	0.1	10^{-5}	0.04	3×10^{-6}
		Total body	10	0.4	3×10^{-5}	0.1	10^{-5}
		Liver	20	0.5	4×10^{-5}	0.2	10^{-5}
	(insol.)	**GI (ULI)**		**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			5×10^{-6}		2×10^{-6}
$_{29}Cu^{64}$ $\beta^-, \beta^+, \epsilon$	(sol.)	**GI (LLI)**		**0.01**	**2×10^{-6}**	**3×10^{-3}**	**7×10^{-7}**
		Spleen	10	0.08	6×10^{-6}	0.03	2×10^{-6}
		Kidney	30	0.2	2×10^{-5}	0.07	5×10^{-6}
		Total body	80	0.5	4×10^{-5}	0.2	10^{-5}
		Liver	100	0.6	5×10^{-5}	0.2	2×10^{-5}
		Heart	200	0.9	7×10^{-5}	0.3	3×10^{-5}
		Brain	600	4	3×10^{-4}	1	10^{-4}
	(insol.)	**GI (LLI)**		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Lung			7×10^{-6}		3×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{30}Zn^{65}$ $\beta^+, \epsilon, \gamma$	(sol.)	**Total body**	60	**3×10^{-3}**	**10^{-7}**	**10^{-3}**	**4×10^{-8}**
		Prostate	70	**4×10^{-3}**	**10^{-7}**	**10^{-3}**	**4×10^{-8}**
		Liver	80	**4×10^{-3}**	**10^{-7}**	**10^{-3}**	**5×10^{-8}**
		Kidney	100	6×10^{-3}	2×10^{-7}	2×10^{-3}	7×10^{-8}
		GI (LLI)		6×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
		Pancreas	200	7×10^{-3}	3×10^{-7}	3×10^{-3}	9×10^{-8}
		Muscle	200	0.01	4×10^{-7}	4×10^{-3}	10^{-7}
		Ovary	300	0.01	5×10^{-7}	4×10^{-3}	2×10^{-7}
		Testis	400	0.02	6×10^{-7}	6×10^{-3}	2×10^{-7}
		Bone	700	0.04	10^{-6}	0.01	4×10^{-7}
	(insol.)	**Lung**			**6×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{30}Zn^{69m}$ γ, e^-, β^-	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	2×10^{-7}
		Prostate	0.7	0.01	**4×10^{-7}**	4×10^{-3}	**10^{-7}**
		Pancreas	5	0.07	3×10^{-6}	0.02	9×10^{-7}
		Liver	8	0.1	5×10^{-6}	0.05	2×10^{-6}
		Kidney	10	0.2	8×10^{-6}	0.07	3×10^{-6}
		Ovary	10	0.2	8×10^{-6}	0.07	3×10^{-6}
		Total body	30	0.5	2×10^{-5}	0.2	6×10^{-6}
		Testis	30	0.5	2×10^{-5}	0.2	6×10^{-6}
		Bone	40	0.6	2×10^{-5}	0.2	7×10^{-6}
		Muscle	100	2	8×10^{-5}	0.7	3×10^{-5}
	(insol.)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Lung			2×10^{-6}		8×10^{-7}
$_{30}Zn^{69}$ β^-	(sol.)	**GI (S)**		**0.05**	10^{-5}	**0.02**	4×10^{-6}
		Prostate	0.8	0.2	**7×10^{-6}**	0.07	**2×10^{-6}**
		Pancreas	5	1	5×10^{-5}	0.5	2×10^{-5}
		Liver	10	3	10^{-4}	1	4×10^{-5}
		Ovary	20	4	10^{-4}	1	5×10^{-5}
		Kidney	20	4	2×10^{-4}	2	5×10^{-5}
		Testis	30	9	3×10^{-4}	3	10^{-4}
		Bone	40	10	4×10^{-4}	3	10^{-4}
		Total body	50	10	5×10^{-4}	5	2×10^{-4}
		Muscle	200	60	2×10^{-3}	20	7×10^{-4}
	(insol.)	**GI (S)**		**0.05**	**9×10^{-6}**	**0.02**	**3×10^{-6}**
		Lung			5×10^{-5}		2×10^{-5}
$_{31}Ga^{72}$ β^-, γ	(sol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**8×10^{-8}**
		Liver	5	9	4×10^{-6}	3	10^{-6}
		Total body	10	20	8×10^{-6}	6	3×10^{-6}
		Bone	10	20	10^{-5}	8	3×10^{-6}
		Spleen	10	20	10^{-5}	8	4×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
		Kidney	10	20	10^{-5}	8	4×10^{-6}
	(insol.)	**GI (LLI)**		$\mathbf{10^{-3}}$	$\mathbf{2 \times 10^{-7}}$	$\mathbf{4 \times 10^{-4}}$	$\mathbf{6 \times 10^{-8}}$
		Lung			10^{-6}		4×10^{-7}
$_{32}Ge^{71}$	(sol.)	**GI (LLI)**		**0.05**	$\mathbf{10^{-5}}$	**0.02**	$\mathbf{4 \times 10^{-6}}$
ϵ		Kidney	100	10	5×10^{-5}	4	2×10^{-5}
		Liver	10^3	100	6×10^{-4}	50	2×10^{-4}
		Total body	2×10^3	200	9×10^{-4}	70	3×10^{-4}
	(insol.)	**Lung**			$\mathbf{6 \times 10^{-6}}$		$\mathbf{2 \times 10^{-6}}$
		GI (LLI)		**0.05**	8×10^{-6}	**0.02**	3×10^{-6}
$_{33}As^{73}$	(sol.)	**GI (LLI)**		**0.01**	3×10^{-6}	$\mathbf{5 \times 10^{-3}}$	10^{-6}
ϵ, γ		**Total body**	300	0.2	$\mathbf{2 \times 10^{-6}}$	0.06	$\mathbf{7 \times 10^{-7}}$
		Kidney	600	0.3	4×10^{-6}	0.1	10^{-6}
		Liver	10^3	0.5	6×10^{-6}	0.2	2×10^{-6}
	(insol.)	**Lung**			$\mathbf{4 \times 10^{-7}}$		$\mathbf{10^{-7}}$
		GI (LLI)		**0.01**	2×10^{-6}	$\mathbf{5 \times 10^{-3}}$	8×10^{-7}
$_{33}As^{74}$	(sol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{3 \times 10^{-7}}$	$\mathbf{5 \times 10^{-4}}$	$\mathbf{10^{-7}}$
$\beta^-, \beta^+, \epsilon, \gamma$		Total body	40	0.07	8×10^{-7}	0.02	3×10^{-7}
		Kidney	80	0.1	2×10^{-6}	0.05	6×10^{-7}
		Liver	100	0.2	3×10^{-6}	0.08	10^{-6}
	(insol.)	**Lung**			$\mathbf{10^{-7}}$		$\mathbf{4 \times 10^{-8}}$
		GI (LLI)		$\mathbf{2 \times 10^{-3}}$	3×10^{-7}	$\mathbf{5 \times 10^{-4}}$	$\mathbf{9 \times 10^{-8}}$
$_{33}As^{76}$	(sol.)	**GI (LLI)**		$\mathbf{6 \times 10^{-4}}$	$\mathbf{10^{-7}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{4 \times 10^{-8}}$
β^-, γ		Total body	20	0.4	5×10^{-6}	0.1	2×10^{-6}
		Kidney	20	0.6	8×10^{-6}	0.2	3×10^{-6}
		Liver	40	1	10^{-5}	0.4	5×10^{-6}
	(insol.)	**GI (LLI)**		$\mathbf{6 \times 10^{-4}}$	$\mathbf{10^{-7}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{3 \times 10^{-8}}$
		Lung			6×10^{-7}		2×10^{-7}
$_{33}As^{77}$	(sol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{5 \times 10^{-7}}$	$\mathbf{8 \times 10^{-4}}$	$\mathbf{2 \times 10^{-7}}$
β^-, γ		Total body	80	2	2×10^{-5}	0.5	7×10^{-6}
		Kidney	100	2	2×10^{-5}	0.7	8×10^{-6}
		Liver	200	4	5×10^{-5}	1	2×10^{-5}
	(insol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{8 \times 10^{-4}}$	$\mathbf{10^{-7}}$
		Lung			2×10^{-6}		6×10^{-7}
$_{34}Se^{75}$	(sol.)	**Kidney**	90	$\mathbf{9 \times 10^{-3}}$	$\mathbf{10^{-6}}$	$\mathbf{3 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$
ϵ, γ		**Total body**	100	0.01	$\mathbf{10^{-6}}$	$\mathbf{3 \times 10^{-3}}$	5×10^{-7}

Radionuclide and type of decay	Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hr week		For 168 hr week	
			$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
	Liver	100	0.01	2×10^{-6}	4×10^{-3}	5×10^{-7}
	Spleen	200	0.02	3×10^{-6}	8×10^{-3}	10^{-6}
	GI (LLI)		0.07	2×10^{-5}	0.03	6×10^{-6}
(insol.)	**Lung**			**10^{-7}**		**4×10^{-8}**
	GI (LLI)		**8×10^{-3}**	10^{-6}	**3×10^{-3}**	5×10^{-7}
$_{35}Br^{82}$ (sol.) β^-, γ	**Total body**	10	**8×10^{-3}**	**10^{-6}**	**3×10^{-3}**	**4×10^{-7}**
	GI (SI)		**8×10^{-3}**	2×10^{-6}	**3×10^{-3}**	6×10^{-7}
(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**6×10^{-8}**
	Lung			6×10^{-7}		2×10^{-7}
$_{36}Kr^{85m}$ (submersion) β^-, γ	**Total body**			**6×10^{-6}**		**10^{-6}**
$_{36}Kr^{85}$ (submersion) β^-	**Total body**			**10^{-5}**		**3×10^{-6}**
$_{36}Kr^{87}$ (submersion) β^-, γ	**Total body**			**10^{-6}**		**2×10^{-7}**
$_{37}Rb^{86}$ (sol.) β^-, γ	**Total body**	30	**2×10^{-3}**	**3×10^{-7}**	**7×10^{-4}**	**10^{-7}**
	Pancreas	30	**2×10^{-3}**	**3×10^{-7}**	**7×10^{-4}**	**10^{-7}**
	Liver	40	3×10^{-3}	4×10^{-7}	10^{-3}	**10^{-7}**
	Spleen	50	3×10^{-3}	5×10^{-7}	10^{-3}	2×10^{-7}
	Muscle	70	5×10^{-3}	7×10^{-7}	2×10^{-3}	2×10^{-7}
	GI (LLI)		0.01	3×10^{-6}	5×10^{-3}	10^{-6}
(insol.)	**Lung**			**7×10^{-8}**		**2×10^{-8}**
	GI (LLI)		**7×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
$_{37}Rb^{87}$ (sol.) β^-	**Pancreas**	200	**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
	Total body	200	4×10^{-3}	6×10^{-7}	2×10^{-3}	**2×10^{-7}**
	Liver	200	5×10^{-3}	7×10^{-7}	2×10^{-3}	**2×10^{-7}**
	Muscle	400	7×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
	Spleen	400	7×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
	GI (LLI)		0.1	2×10^{-5}	0.03	8×10^{-6}
(insol.)	**Lung**			**7×10^{-8}**		**2×10^{-8}**
	GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{38}Sr^{85m}$ (sol.) ϵ, γ	**GI (SI)**		**0.2**	**4×10^{-5}**	**0.07**	**10^{-5}**
	Total body	50	3	2×10^{-4}	1	8×10^{-5}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
		Bone	70	5	4×10^{-4}	2	10^{-4}
	(insol.)	**GI (SI)**		**0.2**	$\mathbf{3 \times 10^{-5}}$	**0.07**	$\mathbf{10^{-5}}$
		Lung			9×10^{-5}		3×10^{-5}
$_{38}Sr^{85}$	(sol.)	**Total body**	60	$\mathbf{3 \times 10^{-3}}$	$\mathbf{2 \times 10^{-7}}$	$\mathbf{10^{-3}}$	$\mathbf{8 \times 10^{-8}}$
ϵ, γ		Bone	70	4×10^{-3}	4×10^{-7}	2×10^{-3}	10^{-7}
		GI (LLI)		7×10^{-3}	2×10^{-6}	2×10^{-3}	5×10^{-7}
	(insol.)	**Lung**			$\mathbf{10^{-7}}$		$\mathbf{4 \times 10^{-8}}$
		GI (LLI)		$\mathbf{5 \times 10^{-3}}$	9×10^{-7}	$\mathbf{2 \times 10^{-3}}$	3×10^{-7}
$_{38}Sr^{89}$	(sol.)	**Bone**	4	$\mathbf{3 \times 10^{-4}}$	$\mathbf{3 \times 10^{-8}}$	$\mathbf{10^{-4}}$	$\mathbf{10^{-8}}$
β^-		GI (LLI)		10^{-3}	3×10^{-7}	4×10^{-4}	9×10^{-8}
		Total body	40	2×10^{-3}	2×10^{-7}	7×10^{-4}	6×10^{-8}
	(insol.)	**Lung**			$\mathbf{4 \times 10^{-8}}$		$\mathbf{10^{-8}}$
		GI (LLI)		$\mathbf{8 \times 10^{-4}}$	10^{-7}	$\mathbf{3 \times 10^{-4}}$	$\mathbf{5 \times 10^{-8}}$
$_{38}Sr^{90}$	(sol.)	**Bone**	2	$\mathbf{4 \times 10^{-6}}$	$\mathbf{3 \times 10^{-10}}$	$\mathbf{10^{-6}}$	$\mathbf{10^{-10}}$
β^-		Total body	20	10^{-5}	9×10^{-10}	4×10^{-6}	3×10^{-10}
		GI (LLI)		10^{-3}	3×10^{-7}	5×10^{-4}	10^{-7}
	(insol.)	**Lung**			$\mathbf{5 \times 10^{-9}}$		$\mathbf{2 \times 10^{-9}}$
		GI (LLI)		$\mathbf{10^{-3}}$	2×10^{-7}	$\mathbf{4 \times 10^{-4}}$	$\mathbf{6 \times 10^{-8}}$
$_{38}Sr^{91}$	(sol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{7 \times 10^{-4}}$	$\mathbf{2 \times 10^{-7}}$
β^-, γ		Bone	3	0.02	2×10^{-6}	7×10^{-3}	5×10^{-7}
		Total body	9	0.07	6×10^{-6}	0.02	2×10^{-6}
	(insol.)	**GI (LLI)**		$\mathbf{10^{-3}}$	$\mathbf{3 \times 10^{-7}}$	$\mathbf{5 \times 10^{-4}}$	$\mathbf{9 \times 10^{-8}}$
		Lung			10^{-6}		4×10^{-7}
$_{38}Sr^{92}$	(sol.)	**GI (ULI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{7 \times 10^{-4}}$	$\mathbf{2 \times 10^{-7}}$
β^-, γ		Bone	2	0.05	4×10^{-6}	0.02	2×10^{-6}
		Total body	8	0.2	2×10^{-5}	0.07	6×10^{-6}
	(insol.)	**GI (ULI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{3 \times 10^{-7}}$	$\mathbf{6 \times 10^{-4}}$	$\mathbf{10^{-7}}$
		Lung			3×10^{-6}		10^{-6}
$_{39}Y^{90}$	(sol.)	**GI (LLI)**		$\mathbf{6 \times 10^{-4}}$	$\mathbf{10^{-7}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{4 \times 10^{-8}}$
β^-		Bone	3	10	5×10^{-7}	4	2×10^{-7}
		Total body	20	80	3×10^{-6}	30	10^{-6}
	(insol.)	**GI (LLI)**		$\mathbf{6 \times 10^{-4}}$	$\mathbf{10^{-7}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{3 \times 10^{-8}}$
		Lung			3×10^{-7}		10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{39}Y^{91m}$ β^-, γ	(sol.)	**GI (SI)**		**0.1**	**2×10^{-5}**	**0.03**	**8×10^{-6}**
		Bone	5	10^3	6×10^{-5}	400	2×10^{-5}
		Total body	20	6×10^3	2×10^{-4}	2×10^3	8×10^{-5}
	(insol.)	**GI (SI)**		**0.1**	**2×10^{-5}**	**0.03**	**6×10^{-6}**
		Lung			4×10^{-5}		10^{-5}
$_{39}Y^{91}$ β^-, γ	(sol.)	**GI (LLI)**		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
		Bone	5	0.8	**4×10^{-8}**	0.3	**10^{-8}**
		Total body	30	5	2×10^{-7}	2	8×10^{-8}
	(insol.)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{39}Y^{92}$ β^-, γ	(sol.)	**GI (ULI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Bone	2	100	6×10^{-6}	40	2×10^{-6}
		Total body	10	800	3×10^{-5}	300	10^{-5}
	(insol.)	**GI (ULI)**		**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Lung			3×10^{-6}		10^{-6}
$_{39}Y^{93}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**8×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
		Bone	2	50	2×10^{-6}	20	7×10^{-7}
		Total body	10	250	10^{-5}	90	4×10^{-6}
	(insol.)	**GI (LLI)**		**8×10^{-4}**	**10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
		Lung			10^{-6}		4×10^{-7}
$_{40}Zr^{93}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**0.02**	5×10^{-6}	**8×10^{-3}**	2×10^{-6}
		Bone	100	3	**10^{-7}**	0.9	**4×10^{-8}**
		Kidney	300	6	3×10^{-7}	2	9×10^{-8}
		Spleen	500	10	4×10^{-7}	3	10^{-7}
		Total body	900	20	8×10^{-7}	6	3×10^{-7}
		Liver	10^3	30	10^{-6}	9	4×10^{-7}
	(insol.)	**Lung**			**3×10^{-7}**		**10^{-7}**
		GI (LLI)		**0.02**	**4×10^{-6}**	**8×10^{-3}**	**10^{-6}**
$_{40}Zr^{95}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	10^{-7}
		Total body	20	3	**10^{-7}**	1	**4×10^{-8}**
		Bone	30	4	2×10^{-7}	2	6×10^{-8}
		Kidney	30	4	2×10^{-7}	2	6×10^{-8}
		Liver	40	6	3×10^{-7}	2	9×10^{-8}
		Spleen	40	7	3×10^{-7}	2	10^{-7}
	(insol.)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
$_{40}Zr^{97}$ β^-, γ	(sol.)	**GI (LLI)**		**5×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Bone	5	60	3×10^{-6}	20	10^{-6}
		Kidney	8	100	5×10^{-6}	40	2×10^{-6}
		Total body	9	100	5×10^{-6}	40	2×10^{-6}
		Liver	10	200	7×10^{-6}	60	3×10^{-6}
		Spleen	10	200	8×10^{-6}	60	3×10^{-6}
	(insol.)	**GI (LLI)**		**5×10^{-4}**	**9×10^{-8}**	**2×10^{-4}**	**3×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}
$_{41}Nb^{93m}$ γ, e^-	(sol.)	**GI (LLI)**		**0.01**	3×10^{-6}	**4×10^{-3}**	9×10^{-7}
		Bone	200	3	**10^{-7}**	1	**4×10^{-8}**
		Kidney	300	5	2×10^{-7}	2	7×10^{-8}
		Spleen	400	5	2×10^{-7}	2	8×10^{-8}
		Liver	400	6	3×10^{-7}	2	9×10^{-8}
		Total body	500	8	3×10^{-7}	3	10^{-7}
	(insol.)	**Lung**			**2×10^{-7}**		**5×10^{-8}**
		GI (LLI)		**0 01**	**2×10^{-6}**	**4×10^{-3}**	**7×10^{-7}**
$_{41}Nb^{95}$ β^-, γ	(sol.)	**GI (LLI)**		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	**2×10^{-7}**
		Total body	40	10	**5×10^{-7}**	4	**2×10^{-7}**
		Liver	60	20	7×10^{-7}	6	3×10^{-7}
		Kidney	60	20	8×10^{-7}	6	3×10^{-7}
		Bone	80	20	9×10^{-7}	7	3×10^{-7}
		Spleen	80	20	10^{-6}	7	3×10^{-7}
	(insol.)	**Lung**			**10^{-7}**		**3×10^{-8}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**10^{-3}**	2×10^{-7}
$_{41}Nb^{97}$ β^-, γ	(sol.)	**GI (ULI)**		**0.03**	**6×10^{-6}**	**9×10^{-3}**	**2×10^{-6}**
		Bone	10	2×10^3	9×10^{-5}	700	3×10^{-5}
		Kidney	20	4×10^3	2×10^{-4}	10^3	6×10^{-5}
		Total body	20	4×10^3	2×10^{-4}	10^3	6×10^{-5}
		Liver	30	4×10^3	2×10^{-4}	2×10^3	7×10^{-5}
		Spleen	30	5×10^3	2×10^{-4}	2×10^3	7×10^{-5}
	(insol.)	**GI (ULI)**		**0.03**	**5×10^{-6}**	**9×10^{-3}**	**2×10^{-6}**
		Lung			2×10^{-5}		7×10^{-6}
$_{42}Mo^{99}$ β^-, γ	(sol.)	**Kidney**	8	**5×10^{-3}**	**7×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
		GI (LLI)		**7×10^{-3}**	**2×10^{-6}**	**2×10^{-3}**	**5×10^{-7}**
		Liver	20	0.01	2×10^{-6}	5×10^{-3}	6×10^{-7}
		Total body	40	0.02	3×10^{-6}	8×10^{-3}	10^{-6}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**7×10^{-8}**
		Lung			5×10^{-7}		2×10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{43}Tc^{96m}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**0.4**	**8×10^{-5}**	**0.1**	**3×10^{-5}**
		Kidney	60	3	4×10^{-4}	1	10^{-4}
		Total body	70	4	4×10^{-4}	1	10^{-4}
		Liver	800	40	4×10^{-3}	14	10^{-3}
		Lung	2×10^3	130	0.01	40	5×10^{-3}
		Bone	10^4	700	0.08	200	0.03
		Skin	2×10^4	800	0.09	300	0.03
	(insol.)	**Lung**			**3×10^{-5}**		**10^{-5}**
		GI (LLI)		**0.3**	**5×10^{-5}**	**0.1**	**2×10^{-5}**
$_{43}Tc^{96}$ ϵ, γ	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Kidney	10	0.03	3×10^{-6}	0.01	10^{-6}
		Total body	10	0.03	4×10^{-6}	0.01	10^{-6}
		Liver	200	0.4	4×10^{-5}	0.1	10^{-5}
		Lung	500	1	10^{-4}	0.4	4×10^{-5}
		Bone	2×10^3	4	5×10^{-4}	1	2×10^{-4}
		Skin	10^4	20	3×10^{-3}	9	9×10^{-4}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**5×10^{-4}**	**8×10^{-8}**
		Lung			3×10^{-7}		9×10^{-8}
$_{43}Tc^{97m}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**8×10^{-7}**
		Kidney	20	0.03	4×10^{-6}	0.01	10^{-6}
		Total body	200	0.4	4×10^{-5}	0.1	2×10^{-5}
		Liver	200	0.4	5×10^{-5}	0.1	2×10^{-5}
		Skin	500	1	10^{-4}	0.3	4×10^{-5}
		Bone	700	1	10^{-4}	0.5	5×10^{-5}
		Lung	2×10^3	4	4×10^{-4}	1	2×10^{-4}
	(insol.)	**Lung**			**2×10^{-7}**		**5×10^{-8}**
		GI (LLI)		**5×10^{-3}**	**9×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
$_{43}Tc^{97}$ ϵ	(sol.)	**GI (LLI)**		**0.05**	**10^{-5}**	**0.02**	**4×10^{-6}**
		Kidney	60	0.1	**10^{-5}**	0.04	**4×10^{-6}**
		Liver	800	2	2×10^{-4}	0.5	6×10^{-5}
		Total body	10^3	2	2×10^{-4}	0.6	7×10^{-5}
		Bone	6×10^3	10	10^{-3}	4	4×10^{-4}
		Lung	9×10^3	20	2×10^{-3}	6	7×10^{-4}
		Skin	3×10^4	60	6×10^{-3}	20	2×10^{-3}
	(insol.)	**Lung**			**3×10^{-7}**		**10^{-7}**
		GI (LLI)		**0.02**	**4×10^{-6}**	**8×10^{-3}**	**10^{-6}**
$_{43}Tc^{99m}$ β^-, γ	(sol.)	**GI (ULI)**		**0.2**	**4×10^{-5}**	**0.06**	**10^{-5}**
		Total body	200	2	2×10^{-4}	0.8	9×10^{-5}
		Kidney	800	7	8×10^{-4}	3	3×10^{-4}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
		Liver	10^4	100	0.01	30	4×10^{-3}
		Lung	2×10^4	200	0.02	70	8×10^{-3}
		Bone	10^5	10^3	0.1	400	0.04
		Skin	10^5	10^3	0.1	400	0.04
	(insol.)	**GI (ULI)**		**0.08**	$\mathbf{10^{-5}}$	**0.03**	$\mathbf{5 \times 10^{-6}}$
		Lung			8×10^{-5}		3×10^{-5}
$_{43}Tc^{99}$ β^-	(sol.)	**GI (LLI)**		**0.01**	$\mathbf{2 \times 10^{-6}}$	$\mathbf{3 \times 10^{-3}}$	$\mathbf{7 \times 10^{-7}}$
		Kidney	10	0.02	3×10^{-6}	8×10^{-3}	9×10^{-7}
		Liver	200	0.3	4×10^{-5}	0.1	10^{-5}
		Total body	200	0.4	4×10^{-5}	0.1	10^{-5}
		Skin	400	0.7	7×10^{-5}	0.2	3×10^{-5}
		Bone	500	0.9	9×10^{-5}	0.3	3×10^{-5}
		Lung	2×10^3	4	4×10^{-4}	1	10^{-4}
	(insol.)	**Lung**			$\mathbf{6 \times 10^{-8}}$		$\mathbf{2 \times 10^{-8}}$
		GI (LLI)		$\mathbf{5 \times 10^{-3}}$	8×10^{-7}	$\mathbf{2 \times 10^{-3}}$	3×10^{-7}
$_{44}Ru^{97}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**0.01**	$\mathbf{2 \times 10^{-6}}$	$\mathbf{4 \times 10^{-3}}$	$\mathbf{8 \times 10^{-7}}$
		Kidney	30	0.4	5×10^{-6}	0.1	10^{-6}
		Total body	100	2	3×10^{-5}	0.7	9×10^{-6}
		Bone	900	10	2×10^{-4}	5	6×10^{-5}
	(insol.)	**GI (LLI)**		**0.01**	$\mathbf{2 \times 10^{-6}}$	$\mathbf{3 \times 10^{-3}}$	$\mathbf{6 \times 10^{-7}}$
		Lung			$\mathbf{2 \times 10^{-6}}$		7×10^{-7}
$_{44}Ru^{103}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{5 \times 10^{-7}}$	$\mathbf{8 \times 10^{-4}}$	$\mathbf{2 \times 10^{-7}}$
		Kidney	20	0.08	10^{-6}	0.03	3×10^{-7}
		Total body	50	0.2	3×10^{-6}	0.08	9×10^{-7}
		Bone	100	0.6	7×10^{-6}	0.2	2×10^{-6}
	(insol.)	**Lung**			$\mathbf{8 \times 10^{-8}}$		$\mathbf{3 \times 10^{-8}}$
		GI (LLI)		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{8 \times 10^{-4}}$	$\mathbf{10^{-7}}$
$_{44}Ru^{105}$ β^-, γ, e^-	(sol.)	**GI (ULI)**		$\mathbf{3 \times 10^{-3}}$	$\mathbf{7 \times 10^{-7}}$	$\mathbf{10^{-3}}$	$\mathbf{2 \times 10^{-7}}$
		Kidney	2	0.3	3×10^{-6}	0.09	10^{-6}
		Total body	20	3	4×10^{-5}	0.9	10^{-5}
		Bone	40	6	8×10^{-5}	2	3×10^{-5}
	(insol.)	**GI (ULI)**		$\mathbf{3 \times 10^{-3}}$	$\mathbf{5 \times 10^{-7}}$	$\mathbf{10^{-3}}$	$\mathbf{2 \times 10^{-7}}$
		Lung			4×10^{-6}		10^{-6}
$_{44}Ru^{106}$ β^-, γ	(sol.)	**GI (LLI)**		$\mathbf{4 \times 10^{-4}}$	$\mathbf{8 \times 10^{-8}}$	$\mathbf{10^{-4}}$	$\mathbf{3 \times 10^{-8}}$
		Kidney	3	0.01	10^{-7}	4×10^{-3}	5×10^{-8}
		Bone	10	0.04	5×10^{-7}	0.01	2×10^{-7}
		Total body	10	0.06	7×10^{-7}	0.02	3×10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**Lung**			**6×10^{-9}**		**2×10^{-9}**
		GI (LLI)		**3×10^{-4}**	**6×10^{-8}**	**10^{-4}**	**2×10^{-8}**
$_{45}Rh^{103m}$ γ, e^-	(sol.)	**GI (S)**		**0.4**	**8×10^{-5}**	**0.1**	**3×10^{-5}**
		Kidney	200	20	10^{-3}	7	4×10^{-4}
		Spleen	200	30	2×10^{-3}	10	6×10^{-4}
		Total body	400	40	3×10^{-3}	20	10^{-3}
		Liver	700	80	5×10^{-3}	30	2×10^{-3}
		Bone	10^3	100	9×10^{-3}	50	3×10^{-3}
	(insol.)	**GI (S)**		**0.3**	**6×10^{-5}**	**0.1**	**2×10^{-5}**
		Lung			3×10^{-4}		10^{-4}
$_{45}Rh^{105}$ β^-, γ	(sol.)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Bone	200	8×10^{-3}	5×10^{-5}	3×10^{-3}	2×10^{-5}
		Kidney	40	0.1	9×10^{-6}	0.05	3×10^{-6}
		Spleen	60	0.2	10^{-5}	0.07	5×10^{-6}
		Total body	100	0.4	2×10^{-5}	0.1	7×10^{-6}
		Liver	200	0.6	4×10^{-5}	0.2	10^{-5}
	(insol.)	**GI (LLI)**		**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			2×10^{-6}		8×10^{-7}
$_{46}Pd^{103}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**0.01**	2×10^{-6}	**3×10^{-3}**	8×10^{-7}
		Kidney	20	0.02	**10^{-6}**	**7×10^{-3}**	**5×10^{-7}**
		Spleen	100	0.1	8×10^{-6}	0.04	3×10^{-6}
		Liver	100	0.1	8×10^{-6}	0.04	3×10^{-6}
		Total body	300	0.4	2×10^{-5}	0.1	8×10^{-6}
	(insol.)	**Lung**			**7×10^{-7}**		**3×10^{-7}**
		GI (LLI)		**8×10^{-3}**	10^{-6}	**3×10^{-3}**	5×10^{-7}
$_{46}Pd^{109}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
		Kidney	7	0.06	4×10^{-6}	0.02	10^{-6}
		Spleen	30	0.3	2×10^{-5}	0.09	5×10^{-6}
		Liver	40	0.3	2×10^{-5}	0.1	7×10^{-6}
		Total body	50	0.4	3×10^{-5}	0.1	9×10^{-6}
	(insol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	**10^{-7}**
		Lung			3×10^{-6}		10^{-6}
$_{47}Ag^{105}$ ϵ, γ	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Total body	30	0.6	3×10^{-6}	0.2	10^{-6}
		Kidney	30	0.7	3×10^{-6}	0.2	10^{-6}
		Liver	70	1	6×10^{-6}	0.5	2×10^{-6}
		Bone	200	4	2×10^{-5}	1	6×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**Lung**			**8×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**10^{-3}**	2×10^{-7}
$_{47}Ag^{110m}$ β^-, γ	(sol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
		Kidney	10	0.2	8×10^{-7}	0.06	3×10^{-7}
		Total body	10	0.2	9×10^{-7}	0.07	3×10^{-7}
		Liver	20	0.4	2×10^{-6}	0.1	5×10^{-7}
		Bone	40	0.7	3×10^{-6}	0.2	10^{-6}
	(insol.)	**Lung**			**10^{-8}**		**3×10^{-9}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{47}Ag^{111}$ β^-, γ	(sol.)	**GI (LLI)**		**10^{-3}**	**3×10^{-7}**	**4×10^{-4}**	**10^{-7}**
		Kidney	20	0.7	3×10^{-6}	0.2	10^{-6}
		Total body	50	1	6×10^{-6}	0.5	2×10^{-6}
		Bone	60	2	8×10^{-6}	0.6	3×10^{-6}
		Liver	80	2	10^{-5}	0.8	3×10^{-6}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**8×10^{-8}**
		Lung			3×10^{-7}		9×10^{-8}
$_{48}Cd^{109}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**5×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
		Liver	20	0.05	**5×10^{-8}**	0.02	**2×10^{-8}**
		Kidney	20	0.05	6×10^{-8}	0.02	**2×10^{-8}**
		Total body	200	0.5	5×10^{-7}	0.2	2×10^{-7}
	(insol.)	**Lung**			**7×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{48}Cd^{115m}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**7×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
		Liver	3	0.03	**4×10^{-8}**	0.01	**10^{-8}**
		Kidney	4	0.04	**4×10^{-8}**	0.01	**2×10^{-8}**
		Total body	30	0.4	4×10^{-7}	0.1	10^{-7}
	(insol.)	**Lung**			**4×10^{-8}**		**10^{-8}**
		GI (LLI)		**7×10^{-4}**	10^{-7}	**3×10^{-4}**	4×10^{-8}
$_{48}Cd^{115}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**3×10^{-4}**	**8×10^{-8}**
		Liver	3	0.6	6×10^{-7}	0.2	2×10^{-7}
		Kidney	5	0.8	8×10^{-7}	0.3	3×10^{-7}
		Total body	30	5	5×10^{-6}	2	2×10^{-6}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**6×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}
$_{49}In^{113m}$ γ, e^-	(sol.)	**GI (ULI)**		**0.04**	**8×10^{-6}**	**0.01**	**3×10^{-6}**
		Kidney	30	200	2×10^{-4}	70	6×10^{-5}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
		Spleen	30	200	2×10^{-4}	70	6×10^{-5}
		Liver	50	300	3×10^{-4}	100	9×10^{-5}
		Total body	70	400	4×10^{-4}	200	10^{-4}
		Bone	90	600	5×10^{-4}	200	2×10^{-4}
		Skin	100	900	8×10^{-4}	300	3×10^{-4}
		Thyroid	500	3×10^{3}	3×10^{-3}	10^{3}	10^{-3}
	(insol.)	**GI (ULI)**		**0.04**	**7×10^{-6}**	**0.01**	**2×10^{-6}**
		Lung			5×10^{-5}		2×10^{-5}
$_{49}In^{114m}$ $\beta^-, \epsilon, \gamma, e^-$	(sol.)	**GI (LLI)**		**5×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Kidney	6	0.1	**10^{-7}**	0.04	**4×10^{-8}**
		Spleen	7	0.1	**10^{-7}**	0.04	**4×10^{-8}**
		Liver	10	0.2	2×10^{-7}	0.07	6×10^{-8}
		Bone	10	0.3	2×10^{-7}	0.09	8×10^{-8}
		Skin	20	0.4	3×10^{-7}	0.1	10^{-7}
		Total body	20	0.4	4×10^{-7}	0.1	10^{-7}
		Thyroid	50	0.9	8×10^{-7}	0.3	3×10^{-7}
	(insol.)	**Lung**			**2×10^{-8}**		**7×10^{-9}**
		GI (LLI)		**5×10^{-4}**	8×10^{-8}	**2×10^{-4}**	3×10^{-8}
$_{49}In^{115m}$ β^-, γ, e^-	(sol.)	**GI (ULI)**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**8×10^{-7}**
		Kidney	30	80	7×10^{-5}	30	2×10^{-5}
		Spleen	30	80	7×10^{-5}	30	2×10^{-5}
		Liver	50	100	10^{-4}	40	4×10^{-5}
		Total body	80	200	2×10^{-4}	60	6×10^{-5}
		Thyroid	80	200	2×10^{-4}	70	6×10^{-5}
		Bone	90	200	2×10^{-4}	70	6×10^{-5}
		Skin	100	300	3×10^{-4}	100	10^{-4}
	(insol.)	**GI (ULI)**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**6×10^{-7}**
		Lung			2×10^{-5}		6×10^{-6}
$_{49}In^{115}$ β^-	(sol.)	**GI (LLI)**		**3×10^{-3}**	6×10^{-7}	**9×10^{-4}**	**2×10^{-7}**
		Kidney	30	0.3	**2×10^{-7}**	0.1	**9×10^{-8}**
		Spleen	40	0.4	3×10^{-7}	0.1	10^{-7}
		Liver	50	0.5	4×10^{-7}	0.1	10^{-7}
		Bone	60	0.6	5×10^{-7}	0.2	2×10^{-7}
		Skin	80	0.8	7×10^{-7}	0.3	2×10^{-7}
		Total body	100	1	10^{-6}	0.4	3×10^{-7}
		Thyroid	3×10^{3}	30	2×10^{-5}	9	8×10^{-6}
	(insol.)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**9×10^{-4}**	2×10^{-7}
$_{50}Sn^{113}$	(sol.)	**GI (LLI)**		**2×10^{-3}**	5×10^{-7}	**9×10^{-4}**	2×10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c(/cm^3$
ϵ, γ, e^-		**Bone**	30	**0.02**	**4×10^{-7}**	**6×10^{-3}**	**10^{-7}**
		Total body	60	0.04	8×10^{-7}	0.01	3×10^{-7}
		Prostate	70	0.04	9×10^{-7}	0.02	3×10^{-7}
		Liver	400	0.3	5×10^{-6}	0.09	2×10^{-6}
		Thyroid	10^3	0.9	2×10^{-5}	0.3	6×10^{-6}
	(insol.)	**Lung**			**5×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**2×10^{-3}**	4×10^{-7}	**8×10^{-4}**	10^{-7}
$_{50}Sn^{125}$	(sol.)	**GI (LLI)**		**5×10^{-4}**	10^{-7}	**2×10^{-4}**	**4×10^{-8}**
β^-, γ, e^-		Bone	7	0.02	3×10^{-7}	6×10^{-3}	10^{-7}
		Prostate	10	0.03	6×10^{-7}	9×10^{-3}	2×10^{-7}
		Total body	20	0.05	10^{-6}	0.02	4×10^{-7}
		Liver	100	0.3	7×10^{-6}	0.1	2×10^{-6}
		Thyroid	300	0.8	2×10^{-5}	0.3	5×10^{-6}
	(insol.)	**Lung**			**8×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**5×10^{-4}**	**9×10^{-8}**	**2×10^{-4}**	**3×10^{-8}**
$_{51}Sb^{122}$	(sol.)	**GI (LLI)**		**8×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
β^-, γ		Total body	20	0.3	4×10^{-6}	0.1	10^{-6}
		Lung	40	0.5	6×10^{-6}	0.2	2×10^{-6}
		Bone	40	0.5	6×10^{-6}	0.2	2×10^{-6}
		Liver	10^3	10	2×10^{-4}	4	5×10^{-5}
		Thyroid	3×10^3	40	4×10^{-4}	10	2×10^{-4}
	(insol.)	**GI (LLI)**		**8×10^{-4}**	**10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
		Lung			4×10^{-7}		10^{-7}
$_{51}Sb^{124}$	(sol.)	**GI (LLI)**		**7×10^{-4}**	**2×10^{-7}**	**2×10^{-4}**	**5×10^{-8}**
β^-, γ		**Total body**	10	**0.02**	**2×10^{-7}**	**6×10^{-3}**	**7×10^{-8}**
		Lung	20	0.02	3×10^{-7}	8×10^{-3}	10^{-7}
		Bone	30	0.04	5×10^{-7}	0.01	2×10^{-7}
		Liver	800	1	10^{-5}	0.4	4×10^{-6}
		Thyroid	10^4	20	2×10^{-4}	6	7×10^{-5}
	(insol.)	**Lung**			**2×10^{-8}**		**7×10^{-9}**
		GI (LLI)		**7×10^{-4}**	10^{-7}	**2×10^{-4}**	**4×10^{-8}**
$_{51}Sb^{125}$	(sol.)	**GI (LLI)**		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	**2×10^{-7}**
β^-, γ, e^-		**Lung**	40	**0.04**	**5×10^{-7}**	**0.01**	**2×10^{-7}**
		Total body	60	**0.05**	**6×10^{-7}**	**0.02**	**2×10^{-7}**
		Bone	70	**0.06**	**8×10^{-7}**	**0.02**	**2×10^{-7}**
		Liver	3×10^{-3}	3	3×10^{-5}	0.9	10^{-5}
		Thyroid	7×10^4	60	7×10^{-4}	20	2×10^{-4}
	(insol.)	**Lung**			**3×10^{-8}**		**9×10^{-9}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**10^{-3}**	2×10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{52}Te^{125m}$ γ, e^-	(sol.)	**Kidney**	20	**5×10^{-3}**	**4×10^{-7}**	**2×10^{-3}**	**10^{-7}**
		GI (LLI)		**5×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
		Testis	20	6×10^{-7}	5×10^{-7}	**2×10^{-3}**	2×10^{-7}
		Spleen	50	0.02	10^{-6}	6×10^{-3}	4×10^{-7}
		Liver	100	0.04	3×10^{-6}	0.01	9×10^{-7}
		Total body	100	0.04	3×10^{-6}	0.01	10^{-6}
		Bone	100	0.04	3×10^{-6}	0.02	10^{-6}
		Thyroid	500	0.2	10^{-5}	0.05	4×10^{-6}
	(insol.)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}
$_{52}Te^{127m}$ β^-, γ, e^-	(sol.)	**Kidney**	7	**2×10^{-3}**	**10^{-7}**	**6×10^{-4}**	**5×10^{-8}**
		Testis	7	**2×10^{-3}**	**10^{-7}**	7×10^{-4}	**5×10^{-8}**
		GI (LLI)		**2×10^{-3}**	5×10^{-7}	8×10^{-4}	2×10^{-7}
		Spleen	20	6×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
		Bone	50	0.01	9×10^{-7}	4×10^{-3}	3×10^{-7}
		Liver	50	0.01	10^{-6}	5×10^{-3}	4×10^{-7}
		Total body	60	0.02	10^{-6}	6×10^{-3}	4×10^{-7}
		Thyroid	200	0.05	4×10^{-6}	0.02	10^{-6}
	(insol.)	**Lung**			**4×10^{-8}**		**10^{-8}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**5×10^{-4}**	9×10^{-8}
$_{52}Te^{127}$ β^-	(sol).	**GI (LLI)**		**8×10^{-3}**	**2×10^{-6}**	**3×10^{-3}**	**6×10^{-7}**
		Kidney	20	0.1	10^{-5}	0.05	4×10^{-6}
		Testis	20	0.2	10^{-5}	0.05	4×10^{-6}
		Spleen	50	0.5	4×10^{-5}	0.2	10^{-5}
		Total body	80	0.8	6×10^{-5}	0.3	2×10^{-5}
		Bone	100	1	7×10^{-5}	0.3	2×10^{-5}
		Liver	100	1	9×10^{-5}	0.4	3×10^{-5}
		Thyroid	100	1	10^{-4}	0.5	4×10^{-5}
	(insol.)	**GI (LLI)**		**5×10^{-3}**	**9×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
		Lung			8×10^{-6}		3×10^{-6}
$_{52}Te^{129m}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**10^{-3}**	2×10^{-7}	**3×10^{-4}**	7×10^{-8}
		Kidney	3	**10^{-3}**	**8×10^{-8}**	4×10^{-4}	**3×10^{-8}**
		Testis	3	**10^{-3}**	**9×10^{-8}**	4×10^{-4}	**3×10^{-8}**
		Spleen	10	4×10^{-3}	3×10^{-7}	10^{-3}	9×10^{-8}
		Total body	20	6×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
		Liver	20	8×10^{-3}	6×10^{-7}	3×10^{-3}	2×10^{-7}
		Bone	20	9×10^{-3}	6×10^{-7}	3×10^{-3}	2×10^{-7}
		Thyroid	70	0.03	2×10^{-6}	8×10^{-3}	6×10^{-7}
	(insol.)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (LLI)		**6×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{52}Te^{129}$ β^-, γ, e^-	(sol.)	**GI (S)**		**0.02**	**5×10^{-6}**	**8×10^{-3}**	**2×10^{-6}**
		Kidney	5	0.4	3×10^{-5}	0.1	10^{-5}
		Testis	6	0.4	3×10^{-5}	0.2	10^{-5}
		Spleen	20	1	10^{-4}	0.5	3×10^{-5}
		Total body	20	2	10^{-4}	0.5	4×10^{-5}
		Liver	40	3	2×10^{-4}	1	7×10^{-5}
		Bone	40	3	2×10^{-4}	1	8×10^{-5}
		Thyroid	60	4	3×10^{-4}	1	10^{-4}
	(insol.)	**GI (ULI)**		**0.02**	**4×10^{-6}**	**8×10^{-3}**	**10^{-6}**
		Lung			2×10^{-5}		7×10^{-6}
$_{52}Te^{131m}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Kidney	4	0.01	10^{-6}	5×10^{-3}	3×10^{-7}
		Total body	10	0.04	3×10^{-6}	0.01	10^{-6}
		Spleen	20	0.05	4×10^{-6}	0.02	10^{-6}
		Liver	30	0.09	7×10^{-6}	0.03	2×10^{-6}
		Bone	50	0.1	10^{-5}	0.05	4×10^{-6}
		Thyroid	50	0.2	10^{-5}	0.06	4×10^{-6}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**6×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}
$_{52}Te^{132}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
		Kidney	3	5×10^{-3}	4×10^{-7}	2×10^{-3}	10^{-7}
		Testis	5	7×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
		Total body	10	0.02	10^{-6}	5×10^{-3}	4×10^{-7}
		Spleen	10	0.02	10^{-6}	6×10^{-3}	4×10^{-7}
		Liver	20	0.03	2×10^{-6}	0.01	8×10^{-7}
		Bone	30	0.05	4×10^{-6}	0.02	10^{-6}
		Thyroid	50	0.07	5×10^{-6}	0.02	10^{-6}
	(insol.)	**GI (LLI)**		**6×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Lung			2×10^{-7}		7×10^{-8}
$_{53}I^{126}$ $\beta^-, \epsilon, \gamma$	(sol.)	**Thyroid**	1	**5×10^{-5}**	**8×10^{-9}**	**2×10^{-5}**	**3×10^{-9}**
		Total body	90	6×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
		GI (LLI)		0.05	10^{-5}	0.02	4×10^{-6}
	(insol.)	**Lung**			**3×10^{-7}**		**10^{-7}**
		GI (LLI)		**3×10^{-3}**	**5×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
$_{53}I^{129}$ β^-, γ, e^-	(sol.)	**Thyroid**	3	**10^{-5}**	**2×10^{-9}**	**4×10^{-6}**	**6×10^{-10}**
		Total body	200	2×10^{-3}	2×10^{-7}	5×10^{-4}	7×10^{-8}
		GI (LLI)		0.1	3×10^{-5}	0.04	9×10^{-6}
	(insol.)	**Lung**			**7×10^{-8}**		**2×10^{-8}**

Radionuclide and type of decay	Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hr week		For 168 hr week	
			$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
	GI (LLI)		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	4×10^{-7}
$_{53}I^{131}$ (sol.) β^-, γ, e^-	**Thyroid**	0.7	**6×10^{-5}**	**9×10^{-9}**	**2×10^{-5}**	**3×10^{-9}**
	Total body	50	5×10^{-3}	8×10^{-7}	2×10^{-3}	3×10^{-7}
	GI (LLI)		0.03	7×10^{-6}	0.01	2×10^{-6}
(insol.)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**10^{-7}**
	Lung			**3×10^{-7}**		**10^{-7}**
$_{53}I^{132}$ (sol.) β^-, γ, e^-	**Thyroid**	0.3	**2×10^{-3}**	**2×10^{-7}**	**6×10^{-4}**	**8×10^{-8}**
	GI (SI)		0.01	3×10^{-6}	4×10^{-3}	9×10^{-7}
	Total body	10	0.1	2×10^{-5}	0.04	6×10^{-6}
(insol.)	**GI (ULI)**		**5×10^{-3}**	**9×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
	Lung			7×10^{-6}		2×10^{-6}
$_{53}I^{133}$ (sol.) β^-, γ, e^-	**Thyroid**	0.3	**2×10^{-4}**	**3×10^{-8}**	**7×10^{-5}**	**10^{-8}**
	GI (SI)		0.02	4×10^{-6}	6×10^{-3}	10^{-6}
	Total body	20	0.02	4×10^{-6}	9×10^{-3}	10^{-6}
(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**7×10^{-8}**
	Lung			10^{-6}		4×10^{-7}
$_{53}I^{134}$ (sol.) β^-, γ	**Thyroid**	0.2	**4×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
	GI (S)		0.02	4×10^{-6}	6×10^{-3}	10^{-6}
	Total body	10	0.3	5×10^{-5}	0.1	2×10^{-5}
(insol.)	**GI (S)**		**0.02**	**3×10^{-6}**	**6×10^{-3}**	**10^{-6}**
	Lung			2×10^{-5}		7×10^{-6}
$_{53}I^{135}$ (sol.) β^-, γ, e^-	**Thyroid**	0.3	**7×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
	GI (SI)		0.01	3×10^{-6}	5×10^{-3}	10^{-6}
	Total body	20	0.05	7×10^{-6}	0.02	3×10^{-6}
(insol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	**10^{-7}**
	Lung			3×10^{-6}		10^{-6}
$_{54}Xe^{131m}$ (submersion) γ, e^-	**Total body**			**2×10^{-5}**		**4×10^{-6}**
$_{54}Xe^{133}$ (submersion) γ, e^-	**Total body**			**10^{-5}**		**3×10^{-6}**
$_{54}Xe^{135}$ (submersion) β^-, γ	**Total body**			**4×10^{-6}**		**10^{-6}**
$_{55}Cs^{131}$ (sol.)	**Total body**	700	**0.07**	**10^{-5}**	**0.02**	**4×10^{-6}**

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
ϵ		**Liver**	**800**	**0.09**	**10^{-5}**	**0.03**	**4×10^{-6}**
		Spleen	10^3	0.1	2×10^{-5}	0.04	6×10^{-6}
		Kidney	10^3	0.1	2×10^{-5}	0.05	7×10^{-6}
		Muscle	2×10^3	0.2	3×10^{-5}	0.07	10^{-5}
		GI (SI)		0.5	10^{-4}	0.2	4×10^{-5}
		Bone	8×10^3	0.9	10^{-4}	0.3	4×10^{-5}
		Lung	10^4	1	2×10^{-4}	0.4	5×10^{-5}
	(insol.)	**Lung**			**3×10^{-6}**		**10^{-6}**
		GI (LLI)		**0.03**	5×10^{-6}	**9×10^{-3}**	2×10^{-6}
$_{55}Cs^{134m}$	(sol.)	**GI (S)**		**0.2**	**4×10^{-5}**	**0.06**	**10^{-5}**
β^-, γ, e^-		Total body	100	0.7	10^{-4}	0.3	4×10^{-5}
		Liver	100	1	10^{-4}	0.3	5×10^{-5}
		Spleen	200	1	2×10^{-4}	0.5	7×10^{-5}
		Kidney	200	2	2×10^{-4}	0.6	8×10^{-5}
		Muscle	200	2	2×10^{-4}	0.6	9×10^{-5}
		Bone	600	4	6×10^{-4}	1	2×10^{-4}
		Lung	2×10^3	10	2×10^{-3}	4	6×10^{-4}
	(insol.)	**GI (ULI)**		**0.03**	**6×10^{-6}**	**0.01**	**2×10^{-6}**
		Lung			3×10^{-5}		10^{-5}
$_{55}Cs^{134}$	(sol.)	**Total body**	**20**	**3×10^{-4}**	**4×10^{-8}**	**9×10^{-5}**	**10^{-8}**
β^-, γ		Liver	30	4×10^{-4}	6×10^{-8}	10^{-4}	2×10^{-8}
		Muscle	30	4×10^{-4}	6×10^{-8}	2×10^{-4}	2×10^{-8}
		Spleen	40	6×10^{-4}	9×10^{-8}	2×10^{-4}	3×10^{-8}
		Kidney	90	10^{-3}	2×10^{-7}	4×10^{-4}	6×10^{-8}
		Bone	200	2×10^{-3}	3×10^{-7}	7×10^{-4}	10^{-7}
		Lung	300	4×10^{-3}	5×10^{-7}	10^{-3}	2×10^{-7}
		GI (SI)		0.01	3×10^{-6}	5×10^{-3}	10^{-6}
	(insol.)	**Lung**			**10^{-8}**		**4×10^{-9}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	7×10^{-8}
$_{55}Cs^{135}$	(sol.)	**Liver**	**200**	**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
β^-		**Spleen**	**300**	**4×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Total body	**300**	**4×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Bone	400	6×10^{-3}	8×10^{-7}	2×10^{-3}	3×10^{-7}
		Muscle	500	6×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
		Kidney	600	9×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		Lung	2×10^3	0.03	4×10^{-6}	0.01	10^{-6}
		GI (LLI)		0.1	3×10^{-5}	0.05	10^{-5}
	(insol.)	**GI (LLI)**		**7×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Lung			**9×10^{-8}**		**3×10^{-8}**

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{55}Cs^{136}$ β^-, γ	(sol.)	**Total body**	**30**	$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{9 \times 10^{-4}}$	$\mathbf{10^{-7}}$
		Liver	60	5×10^{-3}	7×10^{-7}	2×10^{-3}	2×10^{-7}
		Spleen	80	7×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
		Muscle	90	8×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		Kidney	100	8×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		GI (SI)		0.02	5×10^{-6}	8×10^{-3}	2×10^{-6}
		Bone	400	0.03	4×10^{-6}	0.01	2×10^{-6}
		Lung	800	0.06	9×10^{-6}	0.02	3×10^{-6}
	(insol.)	**Lung**			$\mathbf{2 \times 10^{-7}}$		$\mathbf{6 \times 10^{-8}}$
		GI (LLI)		$\mathbf{2 \times 10^{-3}}$	3×10^{-7}	$\mathbf{6 \times 10^{-4}}$	10^{-7}
$_{55}Cs^{137}$ β^-, γ, e^-	(sol.)	**Total body**	**30**	$\mathbf{4 \times 10^{-4}}$	$\mathbf{6 \times 10^{-8}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{2 \times 10^{-8}}$
		Liver	**40**	$\mathbf{5 \times 10^{-4}}$	$\mathbf{8 \times 10^{-8}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{3 \times 10^{-8}}$
		Spleen	**50**	$\mathbf{6 \times 10^{-4}}$	$\mathbf{9 \times 10^{-8}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{3 \times 10^{-8}}$
		Muscle	**50**	$\mathbf{7 \times 10^{-4}}$	$\mathbf{10^{-7}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{4 \times 10^{-8}}$
		Bone	100	10^{-3}	2×10^{-7}	5×10^{-4}	7×10^{-8}
		Kidney	100	10^{-3}	2×10^{-7}	5×10^{-4}	8×10^{-8}
		Lung	300	5×10^{-3}	6×10^{-7}	2×10^{-3}	2×10^{-7}
		GI (SI)		0.02	5×10^{-6}	8×10^{-3}	2×10^{-6}
	(insol.)	**Lung**			$\mathbf{10^{-8}}$		$\mathbf{5 \times 10^{-9}}$
		GI (LLI)		$\mathbf{10^{-3}}$	2×10^{-7}	$\mathbf{4 \times 10^{-4}}$	8×10^{-8}
$_{56}Ba^{131}$ ϵ, γ	(sol.)	**GI (LLI)**		$\mathbf{5 \times 10^{-3}}$	$\mathbf{10^{-6}}$	$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$
		Total body	50	0.1	2×10^{-6}	0.03	7×10^{-7}
		Bone	80	0.1	3×10^{-6}	0.05	10^{-6}
		Liver	10^4	20	4×10^{-4}	7	10^{-4}
		Muscle	2×10^4	40	7×10^{-4}	10	2×10^{-4}
		Lung	2×10^4	40	7×10^{-4}	10	2×10^{-4}
		Spleen	3×10^4	60	10^{-3}	20	4×10^{-4}
		Kidney	4×10^4	70	10^{-3}	20	5×10^{-4}
	(insol.)	**Lung**			$\mathbf{4 \times 10^{-7}}$		$\mathbf{10^{-7}}$
		GI (LLI)		$\mathbf{5 \times 10^{-3}}$	$\mathbf{9 \times 10^{-7}}$	$\mathbf{2 \times 10^{-3}}$	3×10^{-7}
$_{56}Ba^{140}$ β^-, γ	(sol.)	**GI (LLI)**		$\mathbf{8 \times 10^{-4}}$	2×10^{-7}	$\mathbf{3 \times 10^{-4}}$	6×10^{-8}
		Bone	4	6×10^{-3}	$\mathbf{10^{-7}}$	2×10^{-3}	$\mathbf{4 \times 10^{-8}}$
		Total body	9	0.01	3×10^{-7}	5×10^{-3}	10^{-7}
		Liver	10^3	2	5×10^{-5}	0.9	2×10^{-5}
		Lung	3×10^3	4	9×10^{-5}	2	3×10^{-5}
		Muscle	3×10^3	5	10^{-4}	2	4×10^{-5}
		Spleen	4×10^3	6	10^{-4}	2	4×10^{-5}
		Kidney	4×10^3	8	2×10^{-4}	3	5×10^{-5}
	(insol.)	**Lung**			$\mathbf{4 \times 10^{-8}}$		$\mathbf{10^{-8}}$
		GI (LLI)		$\mathbf{7 \times 10^{-4}}$	10^{-7}	$\mathbf{2 \times 10^{-4}}$	$\mathbf{4 \times 10^{-8}}$

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
$_{57}La^{140}$ β^-, γ	(sol.)	**GI (LLI)**		**7×10^{-4}**	**2×10^{-7}**	**2×10^{-4}**	**5×10^{-8}**
		Liver	9	50	2×10^{-6}	20	7×10^{-7}
		Bone	10	60	2×10^{-6}	20	8×10^{-7}
		Total body	10	60	2×10^{-6}	20	9×10^{-7}
	(insol.)	**GI (LLI)**		**7×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Lung			4×10^{-7}		10^{-7}
$_{58}Ce^{141}$ β^-, γ	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
		Liver	30	10	**4×10^{-7}**	3	**2×10^{-7}**
		Bone	40	10	**6×10^{-7}**	5	**2×10^{-7}**
		Kidney	70	20	9×10^{-7}	7	3×10^{-7}
		Total body	90	30	10^{-6}	10	4×10^{-7}
	(insol.)	**Lung**			**2×10^{-7}**		**5×10^{-8}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**9×10^{-4}**	2×10^{-7}
$_{58}Ce^{143}$ β^-, γ	(sol.)	**GI (LLI)**		**10^{-3}**	**3×10^{-7}**	**4×10^{-4}**	**9×10^{-8}**
		Liver	7	50	2×10^{-6}	20	7×10^{-7}
		Bone	10	70	3×10^{-6}	20	10^{-6}
		Kidney	20	100	5×10^{-6}	40	2×10^{-6}
		Total body	20	100	6×10^{-6}	50	2×10^{-6}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**7×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}
$_{58}Ce^{144}$ α, β^-, γ	(sol.)	**GI (LLI)**		**3×10^{-4}**	8×10^{-8}	**10^{-4}**	3×10^{-8}
		Bone	5	0.2	**10^{-8}**	0.08	**3×10^{-9}**
		Liver	6	0.3	**10^{-8}**	0.1	**4×10^{-9}**
		Kidney	10	0.5	2×10^{-8}	0.2	7×10^{-9}
		Total body	20	0.7	3×10^{-8}	0.3	10^{-8}
	(insol.)	**Lung**			**6×10^{-9}**		**2×10^{-9}**
		GI (LLI)		**3×10^{-4}**	**6×10^{-8}**	**10^{-4}**	**2×10^{-8}**
$_{59}Pr^{142}$ β^-, γ	(sol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
		Bone	7	80	**4×10^{-6}**	30	10^{-6}
		Liver	9	100	4×10^{-6}	40	2×10^{-6}
		Kidney	20	200	8×10^{-6}	60	3×10^{-6}
		Total body	20	300	10^{-5}	90	4×10^{-6}
	(insol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
		Lung			10^{-6}		4×10^{-7}
$_{59}Pr^{143}$ β^-	(sol.)	**GI (LLI)**		**10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**10^{-7}**
		Bone	20	10	5×10^{-7}	4	2×10^{-7}
		Liver	20	20	7×10^{-7}	5	2×10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
		Kidney	40	30	10^{-6}	9	4×10^{-7}
		Total body	60	40	2×10^{-6}	10	6×10^{-7}
	(insol.)	**Lung**			**2×10^{-7}**		**6×10^{-8}**
		GI (LLI)		**10^{-3}**	3×10^{-7}	**5×10^{-4}**	9×10^{-8}
$_{60}Nd^{144}$ α	(sol.)	**Bone**	0.1	**2×10^{-3}**	**8×10^{-11}**	**7×10^{-4}**	**3×10^{-11}**
		GI (LLI)		**2×10^{-3}**	5×10^{-7}	8×10^{-4}	2×10^{-7}
		Kidney	0.3	4×10^{-3}	2×10^{-10}	10^{-3}	5×10^{-11}
		Liver	0.7	0.01	4×10^{-10}	3×10^{-3}	2×10^{-10}
		Total body	1	0.01	6×10^{-10}	5×10^{-3}	2×10^{-10}
	(insol.)	**Lung**			**3×10^{-10}**		**10^{-10}**
		GI (LLI)		**2×10^{-3}**	4×10^{-7}	**8×10^{-4}**	10^{-7}
$_{60}Nd^{147}$ α, β^-, γ	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Liver	10	8	**4×10^{-7}**	3	**10^{-7}**
		Kidney	20	10	6×10^{-7}	5	2×10^{-7}
		Bone	20	20	8×10^{-7}	6	3×10^{-7}
		Total body	50	40	2×10^{-6}	10	6×10^{-7}
	(insol.)	**Lung**			**2×10^{-7}**		**8×10^{-8}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}
$_{60}Nd^{149}$ β^-, γ	(sol.)	**GI (LLI)**		**8×10^{-3}**	**2×10^{-6}**	**3×10^{-3}**	**6×10^{-7}**
		Liver	3	300	10^{-5}	100	5×10^{-6}
		Kidney	5	600	3×10^{-5}	200	9×10^{-6}
		Bone	7	700	3×10^{-5}	300	10^{-5}
		Total body	20	2×10^3	9×10^{-5}	700	3×10^{-5}
	(insol.)	**GI (ULI)**		**8×10^{-3}**	**10^{-6}**	**3×10^{-3}**	**5×10^{-7}**
		Lung			9×10^{-6}		3×10^{-6}
$_{61}Pm^{147}$ α, β^-	(sol.)	**GI (LLI)**		**6×10^{-3}**	10^{-6}	**2×10^{-3}**	5×10^{-7}
		Bone	60	1	**6×10^{-8}**	0.5	**2×10^{-8}**
		Kidney	200	4	2×10^{-7}	2	7×10^{-8}
		Total body	300	7	3×10^{-7}	2	10^{-7}
		Liver	300	8	4×10^{-7}	3	10^{-7}
	(insol.)	**Lung**			**10^{-7}**		**3×10^{-8}**
		GI (LLI)		**6×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
$_{61}Pm^{149}$ β^-, γ	(sol.)	**GI (LLI)**		**10^{-3}**	**3×10^{-7}**	**4×10^{-4}**	**10^{-7}**
		Bone	20	70	3×10^{-6}	20	10^{-6}
		Kidney	30	100	6×10^{-6}	40	2×10^{-6}
		Total body	40	200	7×10^{-6}	50	2×10^{-6}
		Liver	50	200	10^{-5}	80	3×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
	(insol.)	**GI (LLI)**		$\mathbf{10^{-3}}$	$\mathbf{2 \times 10^{-7}}$	$\mathbf{4 \times 10^{-4}}$	$\mathbf{8 \times 10^{-8}}$
		Lung			7×10^{-7}		3×10^{-7}
$_{62}Sm^{147}$	(sol.)	**Bone**	0.1	$\mathbf{2 \times 10^{-3}}$	$\mathbf{7 \times 10^{-11}}$	$\mathbf{6 \times 10^{-4}}$	$\mathbf{2 \times 10^{-11}}$
α		**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{7 \times 10^{-4}}$	$\mathbf{2 \times 10^{-7}}$
		Kidney	0.6	8×10^{-3}	4×10^{-10}	3×10^{-3}	10^{-10}
		Liver	0.6	9×10^{-3}	4×10^{-10}	3×10^{-3}	10^{-10}
		Total body	0.9	0.01	5×10^{-10}	4×10^{-3}	2×10^{-10}
	(insol.)	**Lung**			$\mathbf{3 \times 10^{-10}}$		$\mathbf{9 \times 10^{-11}}$
		GI (LLI)		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{7 \times 10^{-4}}$	$\mathbf{10^{-7}}$
$_{62}Sm^{151}$	(sol.)	**GI (LLI)**		**0.01**	$\mathbf{2 \times 10^{-6}}$	$\mathbf{4 \times 10^{-3}}$	$\mathbf{8 \times 10^{-7}}$
β^-, γ		**Bone**	100	2	$\mathbf{6 \times 10^{-8}}$	0.5	$\mathbf{2 \times 10^{-8}}$
		Kidney	300	4	2×10^{-7}	2	6×10^{-8}
		Liver	300	5	2×10^{-7}	2	7×10^{-8}
		Total body	500	7	3×10^{-7}	2	10^{-7}
	(insol.)	**Lung**			$\mathbf{10^{-7}}$		$\mathbf{5 \times 10^{-8}}$
		GI (LLI)		**0.01**	2×10^{-6}	$\mathbf{4 \times 10^{-3}}$	7×10^{-7}
$_{62}Sm^{153}$	(sol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{5 \times 10^{-7}}$	$\mathbf{8 \times 10^{-4}}$	$\mathbf{2 \times 10^{-7}}$
β^-, γ		Liver	20	70	3×10^{-6}	30	10^{-6}
		Bone	30	100	6×10^{-6}	50	2×10^{-6}
		Kidney	50	200	10^{-5}	80	4×10^{-6}
		Total body	70	300	10^{-5}	100	5×10^{-6}
	(insol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{8 \times 10^{-4}}$	$\mathbf{10^{-7}}$
		Lung			10^{-6}		5×10^{-7}
$_{63}Eu^{152}$ (9.2 hr)	(sol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{6 \times 10^{-4}}$	$\mathbf{10^{-7}}$
$\beta^-, \epsilon, \gamma$		Liver	8	200	9×10^{-6}	70	3×10^{-6}
		Bone	10	300	10^{-5}	90	4×10^{-6}
		Kidney	10	300	10^{-5}	100	5×10^{-6}
		Total body	20	500	2×10^{-5}	200	8×10^{-6}
	(insol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	$\mathbf{3 \times 10^{-7}}$	$\mathbf{6 \times 10^{-4}}$	$\mathbf{10^{-7}}$
		Lung			3×10^{-6}		9×10^{-7}
$_{63}Eu^{152}$ (13 years)	(sol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-3}}$	5×10^{-7}	$\mathbf{8 \times 10^{-4}}$	$\mathbf{2 \times 10^{-7}}$
$\beta^-, \epsilon, \gamma$		**Kidney**	20	0.3	$\mathbf{10^{-8}}$	0.09	$\mathbf{4 \times 10^{-9}}$
		Total body	30	0.5	2×10^{-8}	0.2	7×10^{-9}
		Bone	30	0.6	3×10^{-8}	0.2	8×10^{-9}
		Liver	80	1.0	6×10^{-8}	0.4	2×10^{-8}
	(insol.)	**Lung**			$\mathbf{2 \times 10^{-8}}$		$\mathbf{6 \times 10^{-9}}$
		GI (LLI)		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{8 \times 10^{-4}}$	$\mathbf{10^{-7}}$

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
$_{63}Eu^{154}$ $\beta^-, \epsilon, \gamma$	(sol.)	**GI (LLI)**		**6×10^{-4}**	10^{-7}	**2×10^{-4}**	**5×10^{-8}**
		Kidney	5	0.09	**4×10^{-9}**	0.03	**10^{-9}**
		Bone	5	0.09	**4×10^{-9}**	0.03	**10^{-9}**
		Total body	20	0.2	10^{-8}	0.08	4×10^{-9}
		Liver	30	0.5	2×10^{-8}	0.2	7×10^{-9}
	(insol.)	**Lung**			**7×10^{-9}**		**2×10^{-9}**
		GI (LLI)		**6×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
$_{63}Eu^{155}$ β^-, γ	(sol.)	**GI (LLI)**		**6×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
		Kidney	70	2	**9×10^{-8}**	0.7	**3×10^{-8}**
		Bone	80	2	10^{-7}	0.8	**3×10^{-8}**
		Total body	100	4	2×10^{-7}	1	5×10^{-8}
		Liver	200	5	2×10^{-7}	2	8×10^{-8}
	(insol.)	**Lung**			**7×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**6×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
$_{64}Gd^{153}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**6×10^{-3}**	10^{-3}	**2×10^{-3}**	5×10^{-7}
		Bone	90	5	**2×10^{-7}**	2	**8×10^{-8}**
		Total body	100	7	3×10^{-7}	2	10^{-7}
		Liver	100	7	3×10^{-7}	2	10^{-7}
	(insol.)	**Lung**			**9×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**6×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
$_{64}Gd^{159}$ β^-, γ	(sol.)	**GI (LLI)**		**2×10^{-3}**	**5×10^{-7}**	**8×10^{-4}**	**2×10^{-7}**
		Bone	20	200	9×10^{-6}	70	3×10^{-6}
		Liver	40	400	2×10^{-5}	200	7×10^{-6}
		Total body	50	700	3×10^{-5}	200	10^{-5}
	(insol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**8×10^{-4}**	**10^{-7}**
		Lung			3×10^{-6}		10^{-6}
$_{65}Tb^{160}$ β^-, γ	(sol.)	**GI (LLI)**		**10^{-3}**	3×10^{-7}	**4×10^{-4}**	10^{-7}
		Bone	20	2	**10^{-7}**	0.8	**3×10^{-8}**
		Kidney	20	3	**10^{-7}**	1	**4×10^{-8}**
		Total body	20	3	**10^{-7}**	1	**5×10^{-8}**
	(insol.)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	8×10^{-8}
$_{66}Dy^{165}$ β^-, γ	(sol.)	**GI (ULI)**		**0.01**	**3×10^{-6}**	**4×10^{-3}**	**9×10^{-7}**
		Bone	10	10^3	5×10^{-5}	400	2×10^{-5}
		Total body	40	4×10^3	2×10^{-4}	10^3	6×10^{-5}
		Liver	60	6×10^3	3×10^{-4}	2×10^3	9×10^{-5}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
	(insol.)	**GI (ULI)**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**7×10^{-7}**
		Lung			2×10^{-5}		6×10^{-6}
$_{66}Dy^{166}$	(sol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**8×10^{-8}**
β^-, γ, e^-		Bone	5	10	6×10^{-7}	4	2×10^{-7}
		Total body	30	70	3×10^{-6}	20	10^{-6}
		Liver	30	80	4×10^{-6}	30	10^{-6}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**7×10^{-8}**
		Lung			3×10^{-7}		10^{-7}
$_{67}Ho^{166}$	(sol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
β^-, γ, e^-		Bone	5	40	2×10^{-6}	10	6×10^{-7}
		Kidney	20	200	7×10^{-6}	50	2×10^{-6}
		Total body	30	200	10^{-6}	80	4×10^{-7}
		Liver	40	300	10^{-5}	100	4×10^{-6}
	(insol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
		Lung			10^{-6}		3×10^{-7}
$_{68}Er^{169}$	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
β^-, γ		Bone	30	30	10^{-6}	10	5×10^{-7}
		Total body	50	50	2×10^{-6}	20	8×10^{-7}
		Kidney	70	60	3×10^{-6}	20	10^{-6}
		Liver	200	200	9×10^{-6}	70	3×10^{-6}
	(insol.)	**Lung**			**4×10^{-7}**		**10^{-7}**
		GI (LLI)		**3×10^{-3}**	**6×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
$_{68}Er^{171}$	(sol.)	**GI (ULI)**		**3×10^{-3}**	**7×10^{-7}**	**10^{-3}**	**2×10^{-7}**
β^-, γ, e^-		Bone	9	300	10^{-5}	90	4×10^{-6}
		Kidney	30	800	4×10^{-5}	300	10^{-5}
		Total body	30	900	4×10^{-5}	300	10^{-5}
	(insol.)	**GI (ULI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			5×10^{-6}		2×10^{-6}
$_{69}Tm^{170}$	(sol.)	**GI (LLI)**		**10^{-3}**	3×10^{-7}	**5×10^{-4}**	10^{-7}
$\beta^-, \epsilon, \gamma, e^-$		**Bone**	9	0.8	**4×10^{-8}**	0.3	**10^{-8}**
		Kidney	30	4	2×10^{-7}	1	6×10^{-8}
		Total body	60	5	2×10^{-7}	2	7×10^{-8}
	(insol.)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (LLI)		**10^{-3}**	**2×10^{-7}**	**5×10^{-4}**	**8×10^{-8}**
$_{69}Tm^{171}$	(sol.)	**GI (LLI)**		**0.01**	3×10^{-6}	**5×10^{-3}**	10^{-6}
β^-		**Bone**	90	3	**10^{-7}**	0.9	**4×10^{-8}**

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
		Kidney	700	20	8×10^{-7}	6	3×10^{-7}
		Total body	700	20	8×10^{-7}	6	3×10^{-7}
	(insol.)	**Lung**			**2×10^{-7}**		**8×10^{-8}**
		GI (LLI)		**0.01**	3×10^{-6}	**5×10^{-3}**	9×10^{-7}
$_{70}Yb^{175}$ β^-, γ	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Bone	30	60	3×10^{-6}	20	9×10^{-7}
		Kidney	30	80	3×10^{-6}	30	10^{-6}
		Total body	100	300	10^{-5}	100	4×10^{-6}
	(insol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			10^{-6}		4×10^{-7}
$_{71}Lu^{177}$ β^-, γ	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Bone	20	30	10^{-6}	10	4×10^{-7}
		Total body	100	200	7×10^{-6}	60	2×10^{-6}
		Kidney	200	200	10^{-5}	80	3×10^{-6}
	(insol.)	**GI (LLI)**		**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			**7×10^{-7}**		**2×10^{-7}**
$_{72}Hf^{181}$ β^-, γ	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	2×10^{-7}
		Spleen	4	0.9	**4×10^{-8}**	0.3	**10^{-8}**
		Liver	10	2	10^{-7}	0.8	4×10^{-8}
		Total body	40	9	4×10^{-7}	3	10^{-7}
		Kidney	50	10	5×10^{-7}	4	2×10^{-7}
		Bone	100	20	9×10^{-7}	7	3×10^{-7}
	(insol.)	**Lung**			**7×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**2×10^{-3}**	4×10^{-7}	**7×10^{-4}**	10^{-7}
$_{73}Ta^{182}$ β^-, γ	(sol.)	**GI (LLI)**		**10^{-3}**	3×10^{-7}	**4×10^{-4}**	9×10^{-8}
		Liver	7	0.9	**4×10^{-8}**	0.3	**10^{-8}**
		Kidney	20	2	8×10^{-8}	0.7	3×10^{-8}
		Total body	20	2	9×10^{-8}	0.7	3×10^{-8}
		Spleen	30	4	10^{-7}	1	5×10^{-8}
		Bone	50	6	3×10^{-7}	2	9×10^{-8}
	(insol.)	**Lung**			**2×10^{-8}**		**7×10^{-9}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	7×10^{-8}
$_{74}W^{181}$ ϵ, γ	(sol.)	**GI (LLI))**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**8×10^{-7}**
		Liver	70	0.6	2×10^{-5}	0.2	8×10^{-6}
		Total body	100	0.9	3×10^{-5}	0.3	10^{-5}
		Bone	200	2	7×10^{-5}	0.7	2×10^{-5}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
	(insol.)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**0.01**	**2×10^{-6}**	**3×10^{-3}**	**6×10^{-7}**
$_{74}W^{185}$ β^-	(sol.)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Bone	30	0.3	10^{-5}	0.09	3×10^{-6}
		Liver	40	0.4	2×10^{-5}	0.1	5×10^{-6}
		Total body	100	1	5×10^{-5}	0.5	2×10^{-5}
	(insol.)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}
$_{74}W^{187}$ β^-, γ	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	**2×10^{-7}**
		Total body	30	0.5	2×10^{-5}	0.2	7×10^{-6}
		Liver	30	0.6	2×10^{-5}	0.2	8×10^{-6}
		Bone	60	1	4×10^{-5}	0.4	10^{-5}
	(insol.)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Lung			2×10^{-6}		6×10^{-7}
$_{75}Re^{183}$ ϵ, γ	(sol.)	**GI (LLI)**		**0.02**	4×10^{-6}	**6×10^{-3}**	**10^{-6}**
		Total body	80	**0.02**	**3×10^{-6}**	**8×10^{-3}**	**9×10^{-7}**
		Thyroid	300	0.09	10^{-5}	0.03	3×10^{-6}
		Liver	800	0.2	3×10^{-5}	0.08	8×10^{-6}
		Skin	4×10^3	1	10^{-4}	0.4	4×10^{-5}
		Bone	2×10^4	6	6×10^{-4}	2	2×10^{-4}
	(insol.)	**Lung**			**2×10^{-7}**		**5×10^{-8}**
		GI (LLI)		**8×10^{-3}**	10^{-6}	**3×10^{-3}**	5×10^{-7}
$_{75}Re^{186}$ β^-, γ	(sol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
		Thyroid	20	0.01	2×10^{-6}	5×10^{-3}	5×10^{-7}
		Skin	30	0.02	2×10^{-6}	7×10^{-3}	8×10^{-7}
		Total body	50	0.04	4×10^{-6}	0.01	10^{-6}
		Liver	300	0.2	3×10^{-5}	0.08	9×10^{-6}
		Bone	800	0.6	7×10^{-5}	0.2	2×10^{-5}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**5×10^{-4}**	**8×10^{-8}**
		Lung			5×10^{-7}		2×10^{-7}
$_{75}Re^{187}$ β^-	(sol.)	**GI (LLI)**		**0.07**	2×10^{-5}	**0.03**	**6×10^{-6}**
		Skin	300	0.08	**9×10^{-6}**	**0.03**	**3×10^{-6}**
		Thyroid	900	0.2	3×10^{-5}	0.08	9×10^{-6}
		Total body	2×10^3	0.4	5×10^{-5}	0.2	2×10^{-5}
		Liver	6×10^3	2	2×10^{-4}	0.5	6×10^{-5}
		Bone	4×10^4	9	10^{-3}	3	4×10^{-4}
	(insol.)	**Lung**			**5×10^{-7}**		**2×10^{-7}**

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
		GI (LLI)		**0.04**	**7×10^{-6}**	**0.02**	**2×10^{-6}**
$_{75}Re^{188}$ β^-, γ	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Thyroid	7	0.02	2×10^{-6}	7×10^{-3}	7×10^{-7}
		Skin	20	0.05	5×10^{-6}	0.02	2×10^{-6}
		Total body	20	0.06	7×10^{-6}	0.02	2×10^{-6}
		Liver	200	0.5	5×10^{-5}	0.2	2×10^{-5}
		Bone	300	0.9	10^{-4}	0.3	3×10^{-5}
	(insol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
		Lung			10^{-6}		4×10^{-7}
$_{76}Os^{185}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**2×10^{-3}**	**5×10^{-7}**	**7×10^{-4}**	**2×10^{-7}**
		Kidney	8	0.04	10^{-6}	0.01	5×10^{-7}
		Total body	40	0.2	6×10^{-6}	0.06	2×10^{-6}
		Liver	50	0.2	8×10^{-6}	0.08	3×10^{-6}
	(insol.)	**Lung**			**5×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**2×10^{-3}**	**3×10^{-7}**	**7×10^{-4}**	**10^{-7}**
$_{76}Os^{191m}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**0.07**	**2×10^{-5}**	**0.03**	**6×10^{-6}**
		Kidney	100	2	8×10^{-5}	0.8	3×10^{-5}
		Total body	300	7	2×10^{-4}	2	8×10^{-5}
		Liver	600	10	5×10^{-4}	4	2×10^{-4}
	(insol.)	**Lung**			**9×10^{-6}**		**3×10^{-6}**
		GI (LLI)		**0.07**	**10^{-5}**	**0.02**	**4×10^{-6}**
$_{76}Os^{191}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**5×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Kidney	20	0.1	4×10^{-6}	0.04	10^{-6}
		Total body	100	0.6	4×10^{-5}	0.2	8×10^{-6}
		Liver	100	0.7	3×10^{-5}	0.2	9×10^{-6}
	(insol.)	**Lung**			**4×10^{-7}**		**10^{-7}**
		GI (LLI)		**5×10^{-3}**	**8×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
$_{76}Os^{193}$ β^-	(sol.)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Kidney	10	0.1	4×10^{-6}	0.04	2×10^{-6}
		Total body	50	0.6	2×10^{-5}	0.2	7×10^{-6}
		Liver	70	0.9	3×10^{-5}	0.3	10^{-5}
	(insol.)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**9×10^{-8}**
		Lung			10^{-6}		5×10^{-7}
$_{77}Ir^{190}$ ϵ, γ	(sol.)	**GI (LLI)**		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Liver	40	0.04	2×10^{-6}	0.02	5×10^{-7}
		Kidney	40	0.04	2×10^{-6}	0.02	6×10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
		Spleen	40	0.05	2×10^{-6}	0.02	6×10^{-7}
		Total body	50	0.06	2×10^{-6}	0.02	8×10^{-7}
	(insol.)	**Lung**			**4×10^{-7}**		**10^{-7}**
		GI (LLI)		**5×10^{-3}**	**9×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
$_{77}Ir^{192}$	(sol.)	**GI (LLI)**		**10^{-3}**	3×10^{-7}	**4×10^{-4}**	**9×10^{-8}**
β^-, γ		**Kidney**	6	**4×10^{-3}**	**10^{-7}**	**10^{-3}**	**4×10^{-8}**
		Spleen	7	**4×10^{-3}**	**10^{-7}**	**10^{-3}**	**5×10^{-8}**
		Liver	8	5×10^{-3}	2×10^{-7}	2×10^{-3}	6×10^{-8}
		Total body	20	0.01	4×10^{-7}	4×10^{-3}	10^{-7}
	(insol.)	**Lung**			**3×10^{-8}**		**9×10^{-9}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	**6×10^{-8}**
$_{77}Ir^{194}$	(sol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**3×10^{-4}**	**8×10^{-8}**
β^-		Kidney	7	0.08	3×10^{-6}	0.03	10^{-6}
		Liver	8	0.09	3×10^{-6}	0.03	10^{-6}
		Spleen	8	0.09	4×10^{-6}	0.03	10^{-6}
		Total body	20	0.3	10^{-5}	0.1	4×10^{-6}
	(insol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
		Lung			10^{-6}		4×10^{-7}
$_{78}Pt^{191}$	(sol.)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
ϵ, γ		Kidney	10	0.04	10^{-6}	0.01	5×10^{-7}
		Total body	30	0.1	4×10^{-6}	0.03	10^{-6}
		Liver	30	0.1	4×10^{-6}	0.04	2×10^{-6}
		Spleen	70	0.2	8×10^{-6}	0.08	3×10^{-6}
	(insol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			8×10^{-7}		3×10^{-7}
$_{78}Pt^{193m}$	(sol.)	**GI (LLI)**		**0.03**	**7×10^{-6}**	**0.01**	**2×10^{-6}**
ϵ, γ		Kidney	100	0.3	10^{-5}	0.1	4×10^{-6}
		Total body	300	0.8	3×10^{-5}	0.3	10^{-5}
		Liver	300	1	4×10^{-5}	0.3	10^{-5}
		Spleen	600	2	7×10^{-5}	0.7	2×10^{-5}
	(insol.)	**GI (LLI)**		**0.03**	**5×10^{-6}**	**0.01**	**2×10^{-6}**
		Lung			**7×10^{-6}**		**2×10^{-6}**
$_{78}Pt^{193}$	(sol.)	**Kidney**	70	**0.03**	**10^{-6}**	**9×10^{-3}**	**4×10^{-7}**
ϵ		GI (LLI)		0.05	10^{-5}	0.02	4×10^{-6}
		Spleen	500	0.2	6×10^{-6}	0.06	2×10^{-6}
		Total body	500	0.2	6×10^{-6}	0.06	2×10^{-6}
		Liver	600	0.2	9×10^{-6}	0.09	3×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**Lung**			**3×10^{-7}**		**10^{-7}**
		GI (LLI)		**0.05**	**8×10^{-6}**	**0.02**	**3×10^{-6}**
$_{78}Pt^{197m}$ β^-, γ, e^-	(sol.)	**GI (ULI)**		**0.03**	**6×10^{-6}**	**0.01**	**2×10^{-6}**
		Kidney	5	0.8	3×10^{-5}	0.3	10^{-5}
		Liver	20	3	10^{-4}	1	4×10^{-5}
		Spleen	30	5	2×10^{-4}	2	7×10^{-5}
		Total body	40	6	2×10^{-4}	2	7×10^{-5}
	(insol.)	**GI (ULI)**		**0.03**	**5×10^{-6}**	**9×10^{-3}**	**2×10^{-6}**
		Lung			2×10^{-5}		8×10^{-6}
$_{78}Pt^{197}$ β^-, γ	(sol.)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Kidney	10	0.1	5×10^{-6}	0.05	2×10^{-6}
		Liver	40	0.6	2×10^{-5}	0.2	7×10^{-6}
		Spleen	70	0.8	3×10^{-5}	0.3	10^{-5}
		Total body	80	1	4×10^{-5}	0.3	10^{-5}
	(insol.)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			4×10^{-6}		10^{-6}
$_{79}Au^{196}$ β^-, γ, e^-	(sol.)	**GI (LLI)**		**5×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Total body	40	0.07	3×10^{-6}	0.03	9×10^{-7}
		Kidney	50	0.09	4×10^{-6}	0.03	10^{-6}
		Spleen	200	0.3	10^{-5}	0.1	4×10^{-6}
		Liver	200	0.3	10^{-5}	0.1	4×10^{-6}
	(insol.)	**Lung**			**6×10^{-7}**		**2×10^{-7}**
		GI (LLI)		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
$_{79}Au^{198}$ β^-, γ	(sol.)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**10^{-7}**
		Kidney	20	0.07	3×10^{-6}	0.02	9×10^{-7}
		Total body	30	0.1	4×10^{-6}	0.04	2×10^{-6}
		Spleen	60	0.2	8×10^{-6}	0.07	3×10^{-6}
		Liver	80	0.3	10^{-5}	0.1	4×10^{-6}
	(insol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**5×10^{-4}**	**8×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}
$_{79}Au^{199}$ β^-, γ	(sol.)	**GI (LLI)**		**5×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Kidney	70	0.2	8×10^{-6}	0.07	3×10^{-6}
		Total body	100	0.3	10^{-5}	0.1	4×10^{-6}
		Spleen	200	0.6	2×10^{-5}	0.2	8×10^{-6}
		Liver	300	0.8	3×10^{-5}	0.3	10^{-5}
	(insol.)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
		Lung			2×10^{-6}		6×10^{-7}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{80}Hg^{197m}$ ϵ, γ, e^-	(sol.)	**Kidney**	4	**6×10^{-3}**	**7×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
		GI (LLI)		0.02	4×10^{-6}	7×10^{-3}	10^{-6}
		Spleen	40	0.05	7×10^{-6}	0.02	2×10^{-6}
		Liver	50	0.07	9×10^{-6}	0.02	3×10^{-6}
		Total body	70	0.09	10^{-5}	0.03	4×10^{-6}
	(insol.)	**GI (LLI)**		**5×10^{-3}**	**8×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
		Lung			4×10^{-6}		10^{-6}
$_{80}Hg^{197}$ ϵ, γ, e^-	(sol.)	**Kidney**	20	**9×10^{-3}**	**10^{-6}**	**3×10^{-3}**	**4×10^{-7}**
		GI (LLI)		0.06	10^{-5}	0.02	4×10^{-6}
		Spleen	200	0.08	10^{-5}	0.03	4×10^{-6}
		Liver	200	0.1	10^{-5}	0.03	4×10^{-6}
		Total body	200	0.1	2×10^{-5}	0.04	5×10^{-6}
	(insol.)	**GI (LLI)**		**0.01**	**3×10^{-6}**	**5×10^{-3}**	**9×10^{-7}**
		Lung			5×10^{-6}		2×10^{-6}
$_{80}Hg^{203}$ β^-, γ, e^-	(sol.)	**Kidney**	4	**5×10^{-4}**	**7×10^{-8}**	**2×10^{-4}**	**2×10^{-8}**
		Spleen	40	6×10^{-3}	8×10^{-7}	2×10^{-3}	3×10^{-7}
		Liver	40	7×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
		Total body	80	0.01	2×10^{-6}	4×10^{-3}	5×10^{-7}
		GI (LLI)		0.01	3×10^{-6}	4×10^{-3}	10^{-6}
	(insol.)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}
$_{81}Tl^{200}$ ϵ, γ	(sol.)	**GI (LLI)**		**0.01**	**3×10^{-6}**	**4×10^{-3}**	**9×10^{-7}**
		Kidney	40	0.08	8×10^{-6}	0.03	3×10^{-6}
		Total body	50	0.1	10^{-5}	0.04	4×10^{-6}
		Muscle	100	0.3	3×10^{-5}	0.09	9×10^{-6}
		Liver	200	0.4	5×10^{-5}	0.2	2×10^{-5}
		Lung	800	2	2×10^{-4}	0.6	6×10^{-5}
		Bone	10^3	2	2×10^{-4}	0.8	9×10^{-5}
	(insol.)	**GI (LLI)**		**7×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Lung			4×10^{-6}		10^{-6}
$_{81}Tl^{201}$ ϵ, γ, e^-	(sol.)	**GI (LLI)**		**9×10^{-3}**	**2×10^{-6}**	**3×10^{-3}**	**7×10^{-7}**
		Kidney	40	0.04	5×10^{-6}	0.02	2×10^{-6}
		Total body	100	0.1	10^{-5}	0.04	4×10^{-6}
		Muscle	300	0.3	3×10^{-5}	0.1	10^{-5}
		Liver	300	0.3	3×10^{-5}	0.1	10^{-5}
		Bone	400	0.4	5×10^{-5}	0.2	2×10^{-5}
		Lung	10^3	1	10^{-4}	0.4	4×10^{-5}
	(insol.)	**GI (LLI)**		**5×10^{-3}**	**9×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**

Radionuclide and type of decay	Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hr week		For 168 hr week	
			$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	Lung			2×10^{-6}		7×10^{-7}
$_{81}Tl^{202}$ (sol.) ϵ, γ, e^-	**GI (LLI)**		$\mathbf{4 \times 10^{-3}}$	$\mathbf{8 \times 10^{-7}}$	$\mathbf{10^{-3}}$	$\mathbf{3 \times 10^{-7}}$
	Kidney	20	0.01	10^{-6}	3×10^{-3}	4×10^{-7}
	Total body	50	0.03	3×10^{-6}	0.01	10^{-6}
	Muscle	100	0.07	7×10^{-6}	0.02	2×10^{-6}
	Liver	100	0.08	8×10^{-6}	0.03	3×10^{-6}
	Bone	200	0.1	10^{-5}	0.03	4×10^{-6}
	Lung	400	0.3	3×10^{-5}	0.09	9×10^{-6}
(insol.)	**Lung**			$\mathbf{2 \times 10^{-7}}$		$\mathbf{8 \times 10^{-8}}$
	GI (LLI)		$\mathbf{2 \times 10^{-3}}$	$\mathbf{4 \times 10^{-7}}$	$\mathbf{7 \times 10^{-4}}$	$\mathbf{10^{-7}}$
$_{81}Tl^{204}$ (sol.) β^-	**GI (LLI)**		$\mathbf{3 \times 10^{-3}}$	7×10^{-7}	$\mathbf{10^{-3}}$	$\mathbf{2 \times 10^{-7}}$
	Kidney	10	$\mathbf{6 \times 10^{-3}}$	$\mathbf{6 \times 10^{-7}}$	2×10^{-3}	$\mathbf{2 \times 10^{-7}}$
	Total body	80	0.03	3×10^{-6}	0.01	10^{-6}
	Bone	100	0.04	5×10^{-6}	0.02	2×10^{-6}
	Liver	100	0.06	6×10^{-6}	0.02	2×10^{-6}
	Muscle	200	0.07	7×10^{-6}	0.02	3×10^{-6}
	Lung	500	0.2	2×10^{-5}	0.07	7×10^{-6}
(insol.)	**Lung**			$\mathbf{3 \times 10^{-8}}$		$\mathbf{9 \times 10^{-9}}$
	GI (LLI)		$\mathbf{2 \times 10^{-3}}$	3×10^{-7}	$\mathbf{6 \times 10^{-4}}$	10^{-7}
$_{82}Pb^{203}$ (sol.) ϵ, γ	**GI (LLI)**		**0.01**	$\mathbf{3 \times 10^{-6}}$	$\mathbf{4 \times 10^{-3}}$	$\mathbf{9 \times 10^{-7}}$
	Kidney	30	0.1	4×10^{-6}	0.05	10^{-6}
	Total body	90	0.5	10^{-5}	0.2	5×10^{-6}
	Liver	200	1	3×10^{-5}	0.3	10^{-5}
	Bone	400	2	7×10^{-5}	0.8	2×10^{-5}
(insol.)	**GI (LLI)**		**0.01**	$\mathbf{2 \times 10^{-6}}$	$\mathbf{4 \times 10^{-3}}$	$\mathbf{6 \times 10^{-7}}$
	Lung			4×10^{-6}		10^{-6}
$_{82}Pb^{210}$ (sol.) α, β^-, γ	**Kidney**	0.4	$\mathbf{4 \times 10^{-6}}$	10^{-10}	$\mathbf{10^{-6}}$	$\mathbf{4 \times 10^{-11}}$
	Total body	4	$\mathbf{4 \times 10^{-6}}$	10^{-9}	$\mathbf{10^{-6}}$	$\mathbf{4 \times 10^{-10}}$
	Bone	0.7	6×10^{-6}	2×10^{-10}	2×10^{-6}	7×10^{-11}
	Liver	1	10^{-5}	4×10^{-10}	5×10^{-6}	10^{-10}
	GI (LLI)		6×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
(insol.)	**Lung**			$\mathbf{2 \times 10^{-10}}$		$\mathbf{8 \times 10^{-11}}$
	GI (LLI)		$\mathbf{5 \times 10^{-3}}$	$\mathbf{9 \times 10^{-7}}$	$\mathbf{2 \times 10^{-3}}$	$\mathbf{3 \times 10^{-7}}$
$_{82}Pb^{212}$ (sol.) $\alpha, \beta^-, \gamma, e^-$	**Kidney**	0.02	$\mathbf{6 \times 10^{-4}}$	$\mathbf{2 \times 10^{-8}}$	$\mathbf{2 \times 10^{-4}}$	$\mathbf{6 \times 10^{-9}}$
	GI (LLI)		$\mathbf{6 \times 10^{-4}}$	10^{-7}	$\mathbf{2 \times 10^{-4}}$	$\mathbf{4 \times 10^{-8}}$
	Bone	0.1	2×10^{-3}	7×10^{-8}	8×10^{-4}	3×10^{-8}
	Liver	0.2	6×10^{-3}	2×10^{-7}	2×10^{-3}	6×10^{-8}
	Total body	0.2	6×10^{-3}	2×10^{-7}	2×10^{-3}	6×10^{-8}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**Lung**			**2×10^{-8}**		**7×10^{-9}**
		GI (LLI)		**5×10^{-4}**	9×10^{-8}	**2×10^{-4}**	3×10^{-8}
$_{83}Bi^{206}$	(sol.)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	8×10^{-8}
ϵ, γ		**Kidney**	1	0.04	**2×10^{-7}**	0.02	**6×10^{-8}**
		Liver	7	0.2	10^{-6}	0.08	4×10^{-7}
		Total body	10	0.4	2×10^{-6}	0.1	5×10^{-7}
		Spleen	20	0.5	2×10^{-6}	0.2	8×10^{-7}
		Bone	300	10	4×10^{-5}	3	10^{-5}
	(insol.)	**Lung**			**10^{-7}**		**5×10^{-8}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	7×10^{-8}
$_{83}Bi^{207}$	(sol.)	**GI (LLI)**		**2×10^{-3}**	4×10^{-7}	**6×10^{-4}**	10^{-7}
ϵ, γ		**Kidney**	2	0.04	**2×10^{-7}**	0.02	**6×10^{-8}**
		Liver	7	0.1	6×10^{-7}	0.05	2×10^{-7}
		Spleen	20	0.4	2×10^{-6}	0.1	5×10^{-7}
		Total body	20	0.4	2×10^{-6}	0.1	5×10^{-7}
		Bone	300	6	2×10^{-5}	2	8×10^{-6}
	(insol.)	**Lung**			**10^{-8}**		**5×10^{-9}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}
$_{83}Bi^{210}$	(sol.)	**GI (LLI)**		**10^{-3}**	3×10^{-7}	**4×10^{-4}**	9×10^{-8}
α, β^-		**Kidney**	0.04	2×10^{-3}	**6×10^{-9}**	5×10^{-4}	**2×10^{-9}**
		Liver	0.5	0.02	8×10^{-8}	6×10^{-3}	3×10^{-8}
		Spleen	0.6	0.02	10^{-7}	8×10^{-3}	3×10^{-8}
		Total body	20	0.07	3×10^{-7}	0.03	10^{-7}
		Bone	6	0.2	10^{-6}	0.08	3×10^{-7}
	(insol.)	**Lung**			**6×10^{-9}**		**2×10^{-9}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	7×10^{-8}
$_{83}Bi^{212}$	(sol.)	**GI (S)**		**0.01**	2×10^{-6}	**4×10^{-3}**	8×10^{-7}
α, β^-, γ		**Kidney**	0.01	0.02	**10^{-7}**	8×10^{-3}	**3×10^{-8}**
		Liver	0.1	0.3	10^{-6}	0.09	4×10^{-7}
		Spleen	0.2	0.4	10^{-6}	0.1	5×10^{-7}
		Total body	0.2	0.5	2×10^{-6}	0.2	8×10^{-7}
		Bone	0.9	2	8×10^{-6}	0.7	3×10^{-6}
	(insol.)	**Lung**			**2×10^{-7}**		**7×10^{-8}**
		GI (S)		**0.01**	2×10^{-6}	**4×10^{-3}**	6×10^{-7}
$_{84}Po^{210}$	(sol.)	**Spleen**	0.03	**2×10^{-5}**	**5×10^{-10}**	**7×10^{-6}**	**2×10^{-10}**
α		**Kidney**	0.04	**2×10^{-5}**	**5×10^{-10}**	8×10^{-6}	**2×10^{-10}**
		Liver	0.1	7×10^{-5}	2×10^{-9}	3×10^{-5}	6×10^{-10}
		Total body	0.4	2×10^{-4}	5×10^{-9}	8×10^{-5}	2×10^{-9}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
		Bone	0.5	3×10^{-4}	7×10^{-9}	10^{-4}	2×10^{-9}
		GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
	(insol.)	**Lung**			**2×10^{-10}**		**7×10^{-11}**
		GI (LLI)		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{85}At^{211}$	(sol.)	**Thyroid**	0.02	**5×10^{-5}**	**7×10^{-9}**	**2×10^{-5}**	**2×10^{-9}**
α, ϵ, γ		**Ovary**	0.02	**5×10^{-5}**	**7×10^{-9}**	**2×10^{-5}**	3×10^{-9}
		Spleen	0.06	2×10^{-4}	3×10^{-8}	6×10^{-5}	9×10^{-9}
		Total body	0.3	8×10^{-4}	10^{-7}	3×10^{-4}	4×10^{-8}
		GI (S)		0.02	4×10^{-6}	7×10^{-3}	2×10^{-6}
	(insol.)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (ULI)		**2×10^{-3}**	4×10^{-7}	**7×10^{-4}**	10^{-7}
$_{86}Rn^{220}$	*	**Lung**			**3×10^{-7}***		**10^{-7}** *
$\alpha, \beta^-, \gamma, e^-$							
$_{86}Rn^{222}$	*	**Lung**			**3×10^{-8}***		**10^{-8}** *
α, β^-, γ							
$_{88}Ra^{223}$	(sol.)	**Bone**	0.05	**2×10^{-5}**	**2×10^{-9}**	**7×10^{-6}**	**6×10^{-10}**
α, β^-, γ		Total body	0.07	4×10^{-5}	3×10^{-9}	10^{-5}	10^{-9}
		GI (LLI)		2×10^{-4}	4×10^{-8}	6×10^{-5}	10^{-8}
	(insol.)	**Lung**			**2×10^{-10}**		**8×10^{-11}**
		GI (LLI)		**10^{-4}**	2×10^{-8}	**4×10^{-5}**	7×10^{-9}
$_{88}Ra^{224}$	(sol.)	**Bone**	0.06	**7×10^{-5}**	**5×10^{-9}**	**2×10^{-5}**	**2×10^{-9}**
$\alpha, \beta^-, \gamma, e^-$		Total body	0.07	9×10^{-5}	8×10^{-9}	3×10^{-5}	3×10^{-9}
		GI (LLI)		2×10^{-4}	5×10^{-8}	7×10^{-5}	2×10^{-8}
	(insol.)	**Lung**			**7×10^{-10}**		**2×10^{-10}**
		GI (LLI)		**2×10^{-4}**	3×10^{-8}	**5×10^{-5}**	9×10^{-9}
$_{88}Ra^{226}$	(sol.)	**Bone**	0.1	**4×10^{-7}**	**3×10^{-11}**	**10^{-7}**	**10^{-11}**
α, β^-, γ		Total body	0.2	6×10^{-7}	5×10^{-11}	2×10^{-7}	2×10^{-11}
		GI (LLI)		10^{-3}	3×10^{-7}	5×10^{-4}	10^{-7}
	(insol.)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
$_{88}Ra^{228}$	(sol.)	**Bone**	0.06	**8×10^{-7}**	**7×10^{-11}**	**3×10^{-7}**	**2×10^{-11}**
$\alpha, \beta^-, \gamma, e^-$		Total body	0.09	10^{-6}	9×10^{-11}	4×10^{-7}	3×10^{-11}
		GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}

* The daughter elements of Rn^{220} and Rn^{222} are assumed present to the extent they occur in unfiltered air. For all other isotopes the daughter elements are not considered as part of the intake and if present they must be considered on the basis of the rules for mixtures. (See Section IV.6, p. 23.)

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**Lung**			**4×10^{-11}**		**10^{-11}**
		GI (LLI)		**7×10^{-4}**	10^{-7}	**3×10^{-4}**	**4×10^{-8}**
$_{89}Ac^{227}$	(sol.)	**Bone**	0.03	**6×10^{-5}**	**2×10^{-12}**	**2×10^{-5}**	**8×10^{-13}**
α, β^-, γ		Total body	0.1	2×10^{-4}	7×10^{-12}	6×10^{-5}	3×10^{-12}
		Liver	0.2	2×10^{-4}	10^{-11}	8×10^{-5}	3×10^{-12}
		Kidney	0.4	7×10^{-4}	3×10^{-11}	2×10^{-4}	9×10^{-12}
		GI (LLI)		9×10^{-3}	2×10^{-6}	3×10^{-3}	7×10^{-7}
	(insol.)	**Lung**			**3×10^{-11}**		**9×10^{-12}**
		GI (LLI)		**9×10^{-3}**	2×10^{-6}	**3×10^{-3}**	5×10^{-7}
$_{89}Ac^{228}$	(sol.)	**GI (ULI)**		**3×10^{-3}**	6×10^{-7}	**9×10^{-4}**	2×10^{-7}
$\alpha, \beta^-, \gamma, e^-$		**Bone**	0.04	2	9×10^{-8}	0.5	**3×10^{-8}**
		Liver	0.05	2	**8×10^{-8}**	0.6	**3×10^{-8}**
		Total body	0.09	3	10^{-7}	1	5×10^{-8}
		Kidney	0.5	20	6×10^{-7}	6	2×10^{-7}
	(insol.)	**Lung**			**2×10^{-8}**		**6×10^{-9}**
		GI (ULI)		**3×10^{-3}**	4×10^{-7}	**9×10^{-4}**	2×10^{-7}
$_{90}Th^{227}$	(sol.)	**GI (LLI)**		**5×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
α, β^-, γ		**Bone**	0.02	8×10^{-3}	**3×10^{-10}**	3×10^{-3}	**10^{-10}**
		Kidney	0.08	0.04	2×10^{-9}	0.01	6×10^{-10}
		Total body	0.1	0.05	2×10^{-9}	0.02	7×10^{-10}
		Liver	0.5	0.2	10^{-8}	0.08	4×10^{-9}
	(insol.)	**Lung**			**2×10^{-10}**		**6×10^{-11}**
		GI (LLI)		**5×10^{-4}**	9×10^{-8}	**2×10^{-4}**	3×10^{-8}
$_{90}Th^{228}$	(sol.)	**Bone**	0.02	**2×10^{-4}**	**9×10^{-12}**	**7×10^{-5}**	**3×10^{-12}**
$\alpha, \beta^-, \gamma, e^-$		GI (LLI)		4×10^{-4}	8×10^{-8}	10^{-4}	3×10^{-8}
		Kidney	0.09	10^{-3}	5×10^{-11}	4×10^{-4}	2×10^{-11}
		Total body	0.09	10^{-3}	5×10^{-11}	4×10^{-4}	2×10^{-11}
		Liver	0.5	7×10^{-3}	3×10^{-10}	2×10^{-3}	10^{-10}
	(insol.)	**Lung**			**6×10^{-12}**		**2×10^{-12}**
		GI (LLI)		**4×10^{-4}**	7×10^{-8}	**10^{-4}**	2×10^{-8}
$_{90}Th^{230}$	(sol.)	**Bone**	0.05	**5×10^{-5}**	**2×10^{-12}**	**2×10^{-5}**	**8×10^{-13}**
α, γ		Kidney	0.3	10^{-4}	4×10^{-12}	3×10^{-5}	2×10^{-12}
		Total body	0.4	3×10^{-4}	2×10^{-11}	10^{-4}	5×10^{-12}
		Liver	0.6	5×10^{-4}	2×10^{-11}	2×10^{-4}	7×10^{-12}
		GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
	(insol.)	**Lung**			**10^{-11}**		**3×10^{-12}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}

Radionuclide and type of decay	Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hr week		For 168 hr week	
			$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{90}Th^{231}$ (sol.) a, β^-, γ	**GI (LLI)**		**7×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**5×10^{-7}**
	Bone	30	2×10^{-2}	10^{-5}	8×10^{-2}	4×10^{-6}
	Kidney	40	3×10^{-2}	10^{-5}	1×10^{-2}	5×10^{-6}
	Total body	100	9×10^{-2}	4×10^{-5}	3×10^{-2}	10^{-5}
	Liver	300	2×10^{-3}	10^{-4}	8×10^{-2}	3×10^{-5}
(insol.)	**GI (LLI)**		**7×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
	Lung			6×10^{-6}		2×10^{-6}
$_{90}Th^{232}$ * (sol.) a, β^-, γ, e^-	**Bone**	0.04	**5×10^{-5}**	**2×10^{-12}***	**2×10^{-5}**	**7×10^{-13}***
	Kidney	0.3	10^{-4}	5×10^{-12}	4×10^{-5}	2×10^{-12}
	Total body	0.3	3×10^{-4}	10^{-11}	9×10^{-5}	4×10^{-12}
	Liver	0.7	6×10^{-4}	3×10^{-11}	2×10^{-4}	9×10^{-12}
	GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}
(insol.)	**Lung**			**10^{-11}**		**4×10^{-12}**
	GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	7×10^{-8}
$_{90}Th^{234}$ (sol.) β^-, γ	**GI (LLI)**		**5×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
	Bone	4	1	**6×10^{-8}**	0.5	**2×10^{-8}**
	Kidney	6	2	9×10^{-8}	0.7	3×10^{-8}
	Total body	20	8	4×10^{-7}	3	10^{-7}
	Liver	30	10	5×10^{-7}	4	2×10^{-7}
(insol.)	**Lung**			**3×10^{-8}**		**10^{-8}**
	GI (LLI)		**5×10^{-4}**	9×10^{-8}	**2×10^{-4}**	3×10^{-8}
$_{90}Th$–Nat * (sol.) a, β^-, γ, e^-	**Bone**	0.01	**3×10^{-5}**	**2×10^{-12}***	**10^{-5}**	**6×10^{-13}***
	Kidney	0.07	10^{-4}	4×10^{-12}	4×10^{-5}	2×10^{-12}
	Total body	0.07	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
	GI (LLI)		3×10^{-4}	6×10^{-8}	10^{-4}	2×10^{-8}
	Liver	0.3	5×10^{-4}	2×10^{-11}	2×10^{-4}	8×10^{-12}
(insol.)	**Lung**			**4×10^{-12}**		**10^{-12}**
	GI (LLI)		**3×10^{-4}**	5×10^{-8}	**10^{-4}**	2×10^{-8}
$_{91}Pa^{230}$ (sol.) $a, \beta^-, \epsilon, \gamma$	**GI (LLI)**		**7×10^{-3}**	**2×10^{-6}**	**2×10^{-3}**	**5×10^{-7}**
	Bone	0.07	**0.04**	**2×10^{-9}**	**0.01**	**6×10^{-10}**
	Kidney	0.2	0.1	5×10^{-9}	0.04	2×10^{-9}
	Total body	0.3	0.2	8×10^{-9}	0.06	3×10^{-9}

* *Provisional values for* Th^{232} *and* Th-nat. Although calculations and animal experiments suggest that Th-nat, if injected intravenously, is perhaps as hazardous as Pu and indicate the values listed above, experience to date has suggested that in industrial circumstances the hazard of Th-nat is not much greater than that of U-nat. Therefore, pending further investigation the values $(MPC)_a = 3 \times 10^{-11}$ $\mu c/cm^3$ for the 40-hour week and $(MPC)_a = 10^{-11}$ $\mu c/cm^3$ for continuous occupational exposure (168 hr/wk) are recommended as provisional levels, permissible for exposure to inhaled Th-nat or Th^{232}. However, the values given in *Table 1* are listed to indicate the possibility that further evidence may require lower values and to urge especially that exposure levels for these radionuclides be kept as low as is operationally possible. It may be possible to show that similar considerations apply to other inhaled long-lived thorium isotopes under conditions in which the physical characteristics of the airborne particulates are much the same as in the case of Th-nat, and where there is a large amount of airborne material serving as an effective carrier for the thorium.

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**Lung**			**8×10^{-10}**		**3×10^{-10}**
		GI (LLI)		**7×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
$_{91}Pa^{231}$ α, β^-, γ	(sol.)	**Bone**	0.02	**3×10^{-5}**	**10^{-12}**	**9×10^{-6}**	**4×10^{-13}**
		Kidney	0.06	7×10^{-5}	3×10^{-12}	2×10^{-5}	10^{-12}
		Total body	0.1	10^{-4}	5×10^{-12}	4×10^{-5}	2×10^{-12}
		Liver	0.3	4×10^{-4}	2×10^{-11}	10^{-4}	5×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(insol.)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{91}Pa^{233}$ β^-, γ	(sol.)	**GI (LLI)**		**4×10^{-3}**	8×10^{-7}	**10^{-3}**	3×10^{-7}
		Kidney	40	10	**6×10^{-7}**	5	**2×10^{-7}**
		Bone	60	20	9×10^{-7}	7	3×10^{-7}
		Total body	60	20	9×10^{-7}	7	3×10^{-7}
		Liver	200	50	2×10^{-6}	20	8×10^{-7}
	(insol.)	**Lung**			**2×10^{-7}**		**6×10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}
$_{92}U^{230}$ α, β^-, γ	(sol.)	**GI (LLI)**		**10^{-4}**	3×10^{-8}	**5×10^{-5}**	10^{-8}
		Kidney	0.01	7×10^{-3}	**3×10^{-10}**	2×10^{-3}	**10^{-10}**
		Total body	0.06	0.03	10^{-9}	0.01	5×10^{-10}
		Bone	7×10^{-3}	0.04	2×10^{-9}	0.02	6×10^{-10}
	(insol.)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**10^{-4}**	2×10^{-8}	**5×10^{-5}**	8×10^{-9}
$_{92}U^{232}$ $\alpha, \beta^-, \gamma, e^-$	(sol.)	**GI (LLI)**		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
		Bone	0.01	2×10^{-3}	**10^{-10}**	8×10^{-4}	**3×10^{-11}**
		Total body	0.07	6×10^{-3}	3×10^{-10}	2×10^{-3}	10^{-10}
		Kidney	0.04	0.01	6×10^{-10}	4×10^{-3}	2×10^{-10}
	(insol.)	**Lung**			**3×10^{-11}**		**9×10^{-12}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{92}U^{233}$ α, γ	(sol.)	**GI (LLI)**		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	7×10^{-8}
		Bone	0.05	0.01	**5×10^{-10}**	4×10^{-3}	**2×10^{-10}**
		Kidney	0.08	0.03	10^{-9}	0.01	4×10^{-10}
		Total body	0.4	0.04	2×10^{-9}	0.01	5×10^{-10}
	(insol.)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
$_{92}U^{234}$ α, γ	(sol.)	**GI (LLI)**		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	7×10^{-8}
		Bone	0.05	0.01	**6×10^{-10}**	4×10^{-3}	**2×10^{-10}**
		Kidney	0.08	0.03	10^{-9}	0.01	4×10^{-10}
		Total body	0.4	0.04	2×10^{-9}	0.01	6×10^{-10}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
	(insol.)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	**6×10^{-8}**
$_{92}U^{235}$ α, β^-, γ	(sol.)	**GI (LLI)**		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	**6×10^{-8}**
		Kidney	0.03	0.01	**5×10^{-10}**	**4×10^{-3}**	**2×10^{-10}**
		Bone	0.06	0.01	**6×10^{-10}**	**5×10^{-3}**	**2×10^{-10}**
		Total body	0.4	0.04	2×10^{-9}	0.01	6×10^{-10}
	(insol.)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{92}U^{236}$ α, γ	(sol.)	**GI (LLI)**		**10^{-3}**	2×10^{-7}	**3×10^{-4}**	**7×10^{-8}**
		Bone	0.06	0.01	**6×10^{-10}**	**5×10^{-3}**	**2×10^{-10}**
		Kidney	0.08	0.03	10^{-9}	0.01	4×10^{-10}
		Total body	0.4	0.04	2×10^{-9}	0.01	6×10^{-10}
	(insol.)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
$_{92}U^{238}$ α, γ, e^-	(sol.)	**GI (LLI)**		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	8×10^{-8}
		Kidney	5×10^{-3}	2×10^{-3}	**7×10^{-11}**	6×10^{-4}	**3×10^{-11}**
		Bone	0.06	0.01	6×10^{-10}	5×10^{-3}	2×10^{-10}
		Total body	0.5	0.04	2×10^{-9}	0.01	6×10^{-10}
	(insol.)	**Lung**			**10^{-10}**		**5×10^{-11}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	6×10^{-8}
$_{92}U$–Natural $\alpha, \beta^-, \gamma, e^-$	(sol.)	**GI (LLI)**		**5×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
		Kidney	5×10^{-3}	2×10^{-3}	**7×10^{-11}**	6×10^{-4}	**3×10^{-11}**
		Bone	0.03	6×10^{-3}	3×10^{-10}	2×10^{-3}	10^{-10}
		Total body	0.2	0.02	8×10^{-10}	7×10^{-3}	3×10^{-10}
	(insol.)	**Lung**			**6×10^{-11}**		**2×10^{-11}**
		GI (LLI)		**5×10^{-4}**	8×10^{-8}	**2×10^{-4}**	3×10^{-8}
$_{93}Np^{237}$ α, β^-, γ	(sol.)	**Bone**	0.06	**9×10^{-5}**	**4×10^{-12}**	**3×10^{-5}**	**10^{-12}**
		Kidney	0.1	2×10^{-4}	7×10^{-12}	6×10^{-5}	2×10^{-12}
		Total body	0.5	4×10^{-4}	2×10^{-11}	10^{-4}	6×10^{-12}
		Liver	0.5	6×10^{-4}	2×10^{-11}	2×10^{-4}	8×10^{-12}
		GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
	(insol.)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{93}Np^{239}$ α, β^-, γ	(sol.)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Bone	30	100	4×10^{-6}	30	2×10^{-6}
		Kidney	40	200	7×10^{-6}	50	2×10^{-6}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
		Total body	70	300	10^{-5}	90	4×10^{-6}
		Liver	100	500	2×10^{-5}	200	8×10^{-6}
	(insol.)	**GI (LLI)**		**4×10^{-3}**	**7×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			2×10^{-6}		7×10^{-7}
$_{94}Pu^{238}$ α, γ	(sol.)	**Bone**	0.04	**10^{-4}**	**2×10^{-12}**	**5×10^{-5}**	**7×10^{-13}**
		Liver	0.2	6×10^{-4}	8×10^{-12}	2×10^{-4}	3×10^{-12}
		Kidney	0.3	8×10^{-4}	10^{-11}	3×10^{-4}	4×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Total body	0.3	10^{-3}	10^{-11}	4×10^{-4}	5×10^{-12}
	(insol.)	**Lung**			**3×10^{-11}**		**10^{-11}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{94}Pu^{239}$ α, γ	(sol.)	**Bone**	0.04	**10^{-4}**	**2×10^{-12}**	**5×10^{-5}**	**6×10^{-13}**
		Liver	0.4	5×10^{-4}	7×10^{-12}	2×10^{-4}	2×10^{-12}
		Kidney	0.5	7×10^{-4}	9×10^{-12}	2×10^{-4}	3×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Total body	0.4	10^{-3}	10^{-11}	3×10^{-4}	5×10^{-12}
	(insol.)	**Lung**			**4×10^{-11}**		**10^{-11}**
		GI (LLI)		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{94}Pu^{240}$ α, γ	(sol.)	**Bone**	0.04	**10^{-4}**	**2×10^{-12}**	**5×10^{-5}**	**6×10^{-13}**
		Liver	0.4	5×10^{-4}	7×10^{-12}	2×10^{-4}	2×10^{-12}
		Kidney	0.5	7×10^{-4}	9×10^{-12}	2×10^{-4}	3×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Total body	0.4	10^{-3}	10^{-11}	3×10^{-4}	5×10^{-12}
	(insol.)	**Lung**			**4×10^{-11}**		**10^{-11}**
		GI (LLI)		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{94}Pu^{241}$ α, β^-, γ	(sol.)	**Bone**	0.9	**7×10^{-3}**	**9×10^{-11}**	**2×10^{-3}**	**3×10^{-11}**
		Kidney	5	0.04	5×10^{-10}	0.01	2×10^{-10}
		GI (LLI)		0.04	8×10^{-6}	0.01	3×10^{-6}
		Total body	9	0.06	8×10^{-10}	0.02	3×10^{-10}
		Liver	10	0.07	10^{-9}	0.03	3×10^{-10}
	(insol.)	**Lung**			**4×10^{-8}**		**10^{-8}**
		GI (LLI)		**0.04**	7×10^{-6}	**0.01**	2×10^{-6}
$_{94}Pu^{242}$ α	(sol.)	**Bone**	0.05	**10^{-4}**	**2×10^{-12}**	**5×10^{-5}**	**6×10^{-13}**
		Liver	0.4	6×10^{-4}	7×10^{-12}	2×10^{-4}	3×10^{-12}
		Kidney	0.5	7×10^{-4}	10^{-11}	3×10^{-4}	3×10^{-12}
		GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
		Total body	0.4	10^{-3}	10^{-11}	4×10^{-4}	5×10^{-12}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)	$(MPC)_w$ ($\mu c/cm^3$)	$(MPC)_a$ ($\mu c/cm^3$)
	(insol.)	**Lung**			$\mathbf{4 \times 10^{-11}}$		$\mathbf{10^{-11}}$
		GI (LLI)		$\mathbf{9 \times 10^{-4}}$	$\mathbf{2 \times 10^{-7}}$	$\mathbf{3 \times 10^{-4}}$	$\mathbf{5 \times 10^{-8}}$
$_{95}Am^{241}$	(sol.)	**Kidney**	0.1	$\mathbf{10^{-4}}$	$\mathbf{6 \times 10^{-12}}$	$\mathbf{4 \times 10^{-5}}$	$\mathbf{2 \times 10^{-12}}$
α, γ		**Bone**	0.05	$\mathbf{10^{-4}}$	$\mathbf{6 \times 10^{-12}}$	$\mathbf{5 \times 10^{-5}}$	$\mathbf{2 \times 10^{-12}}$
		Liver	0.4	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
		Total body	0.3	4×10^{-4}	2×10^{-11}	10^{-4}	5×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(insol.)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{4 \times 10^{-11}}$
		GI (LLI)		$\mathbf{8 \times 10^{-4}}$	10^{-7}	$\mathbf{3 \times 10^{-4}}$	5×10^{-8}
$_{95}Am^{243}$	(sol.)	**Bone**	0.05	$\mathbf{10^{-4}}$	$\mathbf{6 \times 10^{-12}}$	$\mathbf{4 \times 10^{-5}}$	$\mathbf{2 \times 10^{-12}}$
α, β^-, γ		**Kidney**	0.1	$\mathbf{10^{-4}}$	$\mathbf{6 \times 10^{-12}}$	$\mathbf{5 \times 10^{-5}}$	$\mathbf{2 \times 10^{-12}}$
		Liver	0.4	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
		Total body	0.4	4×10^{-4}	2×10^{-11}	10^{-4}	5×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(insol.)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{4 \times 10^{-11}}$
		GI (LLI)		$\mathbf{8 \times 10^{-4}}$	10^{-7}	$\mathbf{3 \times 10^{-4}}$	5×10^{-8}
$_{96}Cm^{242}$	(sol.)	**GI (LLI)**		$\mathbf{7 \times 10^{-4}}$	2×10^{-7}	$\mathbf{2 \times 10^{-4}}$	5×10^{-8}
α, γ		**Liver**	0.05	$\mathbf{3 \times 10^{-3}}$	$\mathbf{10^{-10}}$	$\mathbf{9 \times 10^{-4}}$	$\mathbf{4 \times 10^{-11}}$
		Bone	0.09	5×10^{-3}	2×10^{-10}	2×10^{-3}	8×10^{-11}
		Kidney	0.2	9×10^{-3}	4×10^{-10}	3×10^{-3}	10^{-10}
		Total body	0.2	0.01	6×10^{-10}	5×10^{-3}	2×10^{-10}
	(insol.)	**Lung**			$\mathbf{2 \times 10^{-10}}$		$\mathbf{6 \times 10^{-11}}$
		GI (LLI)		$\mathbf{7 \times 10^{-4}}$	10^{-7}	$\mathbf{2 \times 10^{-4}}$	4×10^{-8}
$_{96}Cm^{243}$	(sol.)	**Bone**	0.09	$\mathbf{10^{-4}}$	$\mathbf{6 \times 10^{-12}}$	$\mathbf{5 \times 10^{-5}}$	$\mathbf{2 \times 10^{-12}}$
α, γ		Liver	0.2	2×10^{-4}	10^{-11}	8×10^{-5}	3×10^{-12}
		Kidney	0.2	3×10^{-4}	10^{-11}	10^{-4}	4×10^{-12}
		Total body	0.3	5×10^{-4}	2×10^{-11}	2×10^{-4}	7×10^{-12}
		GI (LLI)		7×10^{-4}	2×10^{-7}	2×10^{-4}	5×10^{-8}
	(insol.)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{3 \times 10^{-11}}$
		GI (LLI)		$\mathbf{7 \times 10^{-4}}$	10^{-7}	$\mathbf{2 \times 10^{-4}}$	4×10^{-8}
$_{96}Cm^{244}$	(sol.)	**Bone**	0.1	$\mathbf{2 \times 10^{-4}}$	$\mathbf{9 \times 10^{-12}}$	$\mathbf{7 \times 10^{-5}}$	$\mathbf{3 \times 10^{-12}}$
α, γ		Liver	0.2	3×10^{-4}	10^{-11}	9×10^{-5}	4×10^{-12}
		Kidney	0.2	4×10^{-4}	2×10^{-11}	10^{-4}	6×10^{-12}
		Total body	0.3	6×10^{-4}	3×10^{-11}	2×10^{-4}	9×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(insol.)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{3 \times 10^{-11}}$
		GI (LLI)		$\mathbf{8 \times 10^{-4}}$	10^{-7}	$\mathbf{3 \times 10^{-4}}$	5×10^{-8}

Radionuclide and type of decay		Organ of reference (critical organ **bold face**)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hr week		For 168 hr week	
				$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{96}Cm^{245}$ α, β^-, γ	(sol.)	**Bone**	0.04	$\mathbf{10^{-4}}$	$\mathbf{5 \times 10^{-12}}$	$\mathbf{4 \times 10^{-5}}$	$\mathbf{2 \times 10^{-12}}$
		Liver	0.5	2×10^{-4}	8×10^{-12}	7×10^{-5}	3×10^{-12}
		Kidney	0.2	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
		Total body	0.4	3×10^{-4}	10^{-11}	10^{-4}	5×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(insol.)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{4 \times 10^{-11}}$
		GI (LLI)		$\mathbf{8 \times 10^{-4}}$	10^{-7}	$\mathbf{3 \times 10^{-4}}$	$5 \times \mathbf{10^{-8}}$
$_{96}Cm^{246}$ α	(sol.)	**Bone**	0.05	$\mathbf{10^{-4}}$	$\mathbf{5 \times 10^{-12}}$	$\mathbf{4 \times 10^{-5}}$	$\mathbf{2 \times 10^{-12}}$
		Liver	0.5	2×10^{-4}	8×10^{-12}	7×10^{-5}	3×10^{-12}
		Kidney	0.2	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
		Total body	0.4	3×10^{-4}	10^{-11}	10^{-4}	5×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(insol.)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{4 \times 10^{-11}}$
		GI (LLI)		$\mathbf{8 \times 10^{-4}}$	10^{-7}	$\mathbf{3 \times 10^{-4}}$	$5 \times \mathbf{10^{-8}}$
$_{97}Bk^{249}$ α, β^-, γ	(sol.)	**GI (LLI)**		**0.02**	$4 \times \mathbf{10^{-6}}$	$\mathbf{6 \times 10^{-3}}$	$\mathbf{10^{-6}}$
		Bone	0.7	0.07	$\mathbf{9 \times 10^{-10}}$	0.02	$\mathbf{3 \times 10^{-10}}$
		Total body	5	0.5	7×10^{-9}	0.2	2×10^{-9}
	(insol.)	**Lung**			$\mathbf{10^{-7}}$		$\mathbf{4 \times 10^{-8}}$
		GI (LLI)		**0.02**	3×10^{-6}	$\mathbf{6 \times 10^{-3}}$	10^{-6}
$_{98}Cf^{249}$ α, γ	(sol.)	**Bone**	0.04	$\mathbf{10^{-4}}$	$\mathbf{2 \times 10^{-12}}$	$\mathbf{4 \times 10^{-5}}$	$\mathbf{5 \times 10^{-13}}$
		GI (LLI)		7×10^{-4}	2×10^{-7}	2×10^{-4}	5×10^{-8}
		Total body	0.3	9×10^{-4}	10^{-11}	3×10^{-4}	4×10^{-12}
	(insol.)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{3 \times 10^{-11}}$
		GI (LLI)		$\mathbf{7 \times 10^{-4}}$	10^{-7}	$\mathbf{2 \times 10^{-4}}$	$4 \times \mathbf{10^{-8}}$
$_{98}Cf^{250}$ α	(sol.)	**Bone**	0.04	$\mathbf{4 \times 10^{-4}}$	$\mathbf{5 \times 10^{-12}}$	$\mathbf{10^{-4}}$	$\mathbf{2 \times 10^{-12}}$
		GI (LLI)		7×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Total body	0.3	3×10^{-3}	4×10^{-11}	10^{-3}	10^{-11}
	(insol.)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{3 \times 10^{-11}}$
		GI (LLI)		$\mathbf{7 \times 10^{-4}}$	10^{-7}	$\mathbf{3 \times 10^{-4}}$	$4 \times \mathbf{10^{-8}}$
$_{98}Cf^{252}$ α, γ Spontaneous Fission	(sol.)	**GI (LLI)**		$\mathbf{2 \times 10^{-4}}$	4×10^{-8}	$\mathbf{7 \times 10^{-5}}$	2×10^{-8}
		Bone	0.01	5×10^{-4}	$\mathbf{6 \times 10^{-12}}$	2×10^{-4}	$\mathbf{2 \times 10^{-12}}$
		Total body	0.09	4×10^{-3}	5×10^{-11}	10^{-3}	2×10^{-11}
	(insol.)	**Lung**			$\mathbf{3 \times 10^{-11}}$		$\mathbf{10^{-11}}$
		GI (LLI)		$\mathbf{2 \times 10^{-4}}$	4×10^{-8}	$\mathbf{7 \times 10^{-5}}$	$\mathbf{10^{-8}}$

Table 2. Radionuclides which do not reach equilibrium in the body within 50 years

Z	Radionuclide	T_r (years)	T_b (years)	T (years)	Percentage equil. reached in 50 years
38	Sr^{90}	28	50	18	86
88	Ra^{226}	1622	45	44	56
89	Ac^{227}	21.8	200	20	83
90	Th^{230}	8.0×10^4	200	200	16
90	Th^{232}	1.38×10^{10}	200	200	16
91	Pa^{231}	3.43×10^4	200	200	16
93	Np^{237}	2.20×10^6	200	200	16
94	Pu^{238}	89.6	200	62	43
94	Pu^{239}	2.44×10^4	200	200	16
94	Pu^{240}	6.6×10^3	200	190	16
94	Pu^{241}	13.2	200	12	94
94	Pu^{242}	3.8×10^5	200	200	16
95	Am^{241}	462	200	140	22
95	Am^{243}	8×10^3	200	200	16
96	Cm^{243}	35	200	30	69
96	Cm^{244}	18.4	200	17	87
96	Cm^{245}	2×10^4	200	200	16
96	Cm^{246}	6.6×10^3	200	190	16
98	Cf^{249}	4.7×10^2	200	140	22
98	Cf^{250}	10	200	10	97

Table 3. Maximum permissible concentration of unidentified radionuclides in water, $(MPCU)_w$ values, for continuous occupational exposure*

Limitations	μc/cm³ of water†
If no one of the radionuclides Sr^{90}, I^{126}, I^{129}, I^{131}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ra^{228}, Ac^{227}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat is present, then the $(MPCU)_w$ is	3×10^{-5}
If no one of the radionuclides Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat is present, then the $(MPCU)_w$ is	2×10^{-5}
If no one of the radionuclides Sr^{90}, I^{129}, Pb^{210}, Ra^{226}, and Ra^{228} is present, then the $(MPCU)_w$ is	7×10^{-6}
If neither Ra^{226} nor Ra^{228} is present, then the $(MPCU)_w$ is	10^{-6}
If no analysis of the water is made, then the $(MPCU)_w$ is	10^{-7}

* Each $(MPCU)_w$ value is the smallest value of $(MPC)_w$ in Table 1 for radionuclides other than those listed opposite the value. Thus these $(MPCU)_w$ values are permissible levels for continuous occupational exposure (168 hr/wk) for any radionuclide or mixture of radionuclides where the indicated isotopes are not present (i.e., where the concentration of the radionuclide in water is small compared with the $(MPC)_w$ value for this radionuclide). The $(MPCU)_w$ may be much smaller than the more exact maximum permissible concentration of the material, but the determination of this $(MPC)_w$ requires identification of the radionuclides present and the concentration of each.

† Use one-tenth of these values for interim application in the neighborhood of an atomic energy plant.

Table 4. Maximum permissible concentration of unidentified radionuclides in air, $(MPCU)_a$ values, for continuous occupational exposure*

Limitations	$\mu c/cm^3$ of air†
If there are no α-emitting radionuclides and if no one of the β-emitting radionuclides Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} is present, then the $(MPCU)_a$ is	10^{-9}
If there are no α-emitting radionuclides and if no one of the β-emitting radionuclides Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} is present, then the $(MPCU)_a$ is	10^{-10}
If there are no α-emitting radionuclides and if the α-emitting radionuclide Ac^{227} is not present, then the $(MPCU)_a$ is	10^{-11}
If no one of the radionuclides Ac^{227}, Th^{230}, Pa^{231}, Th^{232}, Th-nat, Pu^{238}, Pu^{239}, Pu^{240}, Pu^{242}, and Cf^{249} is present, then the $(MPCU)_a$ is	10^{-12}
If no one of the radionuclides Pa^{231}, Th-nat, Pu^{239}, Pu^{240}, Pu^{242}, and Cf^{249} is present, then the $(MPCU)_a$ is	7×10^{-13}
If no analysis of the air is made, then the $(MPCU)_a$ is	4×10^{-13}

* Each $(MPCU)_a$ value is the smallest value of $(MPC)_a$ in Table 1 for radionuclides other than those listed opposite the value. Thus these $(MPCU)_a$ values are permissible levels for continuous occupational exposure (168 hr/wk) for any radionuclide or mixture of radionuclides where the indicated isotopes are not present (i.e., where the concentration of the radionuclide in air is small compared with the $(MPC)_a$ value for this radionuclide). The $(MPCU)_a$ value may be much smaller than the more exact maximum permissible concentration of the material, but the determination of this $(MPC)_a$ requires identification of the radionuclides present and the concentration of each.

† Use one-tenth of these values for interim application in the neighborhood of an atomic energy plant.

Table 5. Effective energies

Z	Radionuclide (T_r in days)	Organ of reference*	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)	Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
1	H^3(HTO or H_2^3O)	Total body	0.010			GI (SI)	2.3
	(4.5×10^3)	Submersion	0.010			GI (LI)	1.7
		Body tissue	0.010				
				18	A^{37}	Submersion	0.0026
4	Be^7	Total body	0.035		(34.1)		
	(53.6)	Lung (insol.)	0.016				
		GI (S)	0.016	18	A^{41}	Submersion	1.8
		GI (SI)	0.035		(0.076)		
		GI (LI)	0.0085				
		Kidney	0.012	19	K^{42}	Total body	1.6
		Liver	0.016		(0.52)	Lung (insol.)	1.5
		Bone	0.0085			GI (S)	1.5
		Spleen	0.012			GI (SI)	1.6
						GI (LI)	1.5
6	$C^{14}(CO_2)$	Total body	0.054			Brain	1.5
	(2.0×10^6)	GI (S)	0.054			Spleen	1.5
		GI (SI)	0.054			Muscle	1.6
		GI (LI)	0.054			Liver	1.5
		Submersion	0.054				
		Fat	0.054	20	Ca^{45}	Total body	0.086
		Bone	2.7		(164)	Lung (insol.)	0.086
						GI (S)	0.086
9	F^{18}	Total body	0.89			GI (SI)	0.086
	(0.078)	Lung (insol.)	0.54			GI (LI)	0.086
		GI (S)	0.54			Bone	0.43
		GI (SI)	0.89				
		GI (LI)	0.41	20	Ca^{47}	Total body	1.4
		Bone and teeth	1.4		(4.9)	Lung (insol.)	0.81
					Sc^{47}	Bone	2.6
11	Na^{22}	Total body	1.6		(3.43)		
	(950)	Lung (insol.)	0.80				
		GI (S)	0.80	21	Sc^{46}	Total body	1.3
		GI (SI)	1.6		(85)	Lung (insol.)	0.64
		GI (LI)	0.53			GI (S)	0.64
						GI (SI)	1.3
11	Na^{24}	Total body	2.7			GI (LI)	0.40
	(0.63)	Lung (insol.)	1.5			Liver	0.64

		GI (S)	1.5
		GI (SI)	2.7
		GI (LI)	1.0
14	Si^{31}	Total body	0.59
	(0.11)	Lung (insol.)	0.59
		GI (S)	0.59
		GI (SI)	0.59
		GI (LI)	0.59
		Adrenal	0.59
		Testis	0.59
		Ovary	0.59
		Skin	0.59
		Lung (sol.)	0.59
15	P^{32}	Total body	0.69
	(14.3)	Lung (insol.)	0.69
		GI (S)	0.69
		GI (SI)	0.69
		GI (LI)	0.69
		Liver	0.69
		Bone	3.5
		Brain	0.69
16	S^{35}	Total body	0.056
	(87.1)	Lung (insol.)	0.056
		GI (S)	0.056
		GI (SI)	0.056
		GI (LI)	0.056
		Testis	0.056
		Bone	0.28
		Skin	0.056
17	Cl^{36}	Total body	0.26
	(1.2×10^8)	Lung (insol.)	0.26
		GI (S)	0.26
		GI (SI)	0.26
		GI (LI)	0.26
17	Cl^{38}	Total body	2.3
	(0.026)	Lung (insol.)	1.9
		GI (S)	1.9
		Kidney	0.50
		Bone	0.90
21	Sc^{47}	Total body	0.26
	(3.43)	Lung (insol.)	0.21
		GI (S)	0.21
		GI (SI)	0.26
		GI (LI)	0.19
		Liver	0.21
		Kidney	0.20
		Bone	0.89
21	Sc^{48}	Total body	2.2
	(1.83)	Lung (insol.)	1.1
		GI (S)	1.1
		GI (SI)	2.2
		GI (LI)	0.69
		Kidney	0.85
		Liver	1.1
		Bone	1.6
23	V^{48}	Total body	1.9
	(16.1)	Lung (insol.)	0.90
		GI (S)	0.90
		GI (SI)	1.9
		GI (LI)	0.56
		Kidney	0.70
		Spleen	0.70
		Liver	0.90
		Bone	1.2
24	Cr^{51}	Total body	0.025
	(27.8)	Lung (insol.)	0.014
		GI (S)	0.014
		GI (SI)	0.025
		GI (LI)	0.010
		Lung (sol.)	0.014
		Prostate	0.0084
		Thyroid	0.0084
		Kidney	0.012

* The abbreviations GI, S, SI and LI refer to gastrointestinal tract, stomach, small intestine, and large intestine (either upper or lower large intestine), respectively.

Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
25	Mn^{52} (5.55)	Total body	2.1
		Lung (insol.)	0.96
		GI (S)	0.96
		GI (SI)	2.1
		GI (LI)	0.56
		Pancreas	0.56
		Liver	0.96
25	Mn^{54} (300)	Total body	0.51
		Lung (insol.)	0.23
		GI (S)	0.23
		GI (SI)	0.51
		GI (LI)	0.13
		Liver	0.23
		Pancreas	0.13
25	Mn^{56} (0.11)	Total body	1.9
		Lung (insol.)	1.3
		GI (S)	1.3
		GI (SI)	1.9
		GI (LI)	1.1
		Pancreas	1.1
		Liver	1.3
26	Fe^{55} (1.1×10^3)	Total body	0.0065
		Lung (insol.)	0.0065
		GI (S)	0.0065
		GI (SI)	0.0065
		GI (LI)	0.0065
		Spleen	0.0065
		Liver	0.0065
		Lung (sol.)	0.0065
		Bone	0.0065
26	Fe^{59} (45.1)	Total body	0.81
		Lung (insol.)	0.42
		GI (S)	0.42
		GI (SI)	0.81
		GI (LI)	0.29
		GI (S)	0.0077
		GI (SI)	0.0077
		GI (LI)	0.0077
		Bone	0.0077
		Liver	0.0077
28	Ni^{63} (2.9×10^4)	Total body	0.021
		Lung (insol.)	0.021
		GI (S)	0.021
		GI (SI)	0.021
		GI (LI)	0.021
		Bone	0.11
		Liver	0.021
28	Ni^{65} (0.11)	Total body	1.4
		Lung (insol.)	1.2
		GI (S)	1.2
		GI (SI)	1.4
		GI (LI)	1.1
		Bone	5.3
		Liver	1.2
29	Cu^{64} (0.53)	Total body	0.25
		Lung (insol.)	0.19
		GI (S)	0.19
		GI (SI)	0.25
		GI (LI)	0.16
		Spleen	0.17
		Kidney	0.17
		Liver	0.19
		Heart	0.17
		Brain	0.21
30	Zn^{65} (245)	Total body	0.32
		Lung (insol.)	0.15
		GI (S)	0.15
		GI (SI)	0.32
		GI (LI)	0.084
		Prostate	0.056

		Spleen	0.34
		Liver	0.42
		Lung (sol.)	0.42
27	Co^{57} (270)	Total body	0.090
		Lung (insol.)	0.053
		GI (S)	0.053
		GI (SI)	0.090
		GI (LI)	0.040
		Pancreas	0.040
		Liver	0.053
		Spleen	0.045
		Kidney	0.045
27	Co^{58m} (0.38) Co^{58} (72)	Total body	0.099
		Lung (insol.)	0.20
		Pancreas	0.039
		Liver	0.059
		Spleen	0.048
		Kidney	0.048
27	Co^{58} (72)	Total body	0.61
		Lung (insol.)	0.29
		GI (S)	0.29
		GI (SI)	0.61
		GI (LI)	0.17
		Pancreas	0.17
		Liver	0.29
		Spleen	0.22
		Kidney	0.22
27	Co^{60} (1.9×10^3)	Total body	1.5
		Lung (insol.)	0.72
		GI (S)	0.72
		GI (SI)	1.5
		GI (LI)	0.44
		Pancreas	0.44
		Liver	0.72
		Spleen	0.56
		Kidney	0.56
28	Ni^{59} (2.9×10^7)	Total body	0.0077
		Lung (insol.)	0.0077
		Liver	0.15
		Kidney	0.11
		Pancreas	0.084
		Muscle	0.32
		Ovary	0.056
		Testis	0.056
		Bone	0.094
30	Zn^{69m} (0.58) Zn^{69} (0.036)	Total body	0.64
		Lung (insol.)	0.50
		Prostate	0.43
		Pancreas	0.45
		Liver	0.50
		Kidney	0.47
		Ovary	0.43
		Testis	0.43
		Bone	2.1
		Muscle	0.64
30	Zn^{69} (0.036)	Total body	0.37
		Lung (insol.)	0.37
		GI (S)	0.37
		GI (SI)	0.37
		GI (LI)	0.37
		Prostate	0.37
		Pancreas	0.37
		Liver	0.37
		Ovary	0.37
		Kidney	0.37
		Testis	0.37
		Bone	1.9
		Muscle	0.37
31	Ga^{72} (0.59)	Total body	1.8
		Lung (insol.)	1.1
		GI (S)	1.1
		GI (SI)	1.8
		GI (LI)	0.78
		Liver	1.1
		Spleen	0.89
		Kidney	0.89
		Bone	2.6

Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
32	Ge^{71} (12)	Total body	0.010
		Lung (insol.)	0.010
		GI (S)	0.010
		GI (SI)	0.010
		GI (LI)	0.010
		Kidney	0.010
		Liver	0.010
33	$As^{73} + Ge^{73m}$ (76)	Total body	0.061
		Lung (insol.)	0.041
		GI (S)	0.041
		GI (SI)	0.061
		GI (LI)	0.033
		Kidney	0.036
		Liver	0.041
33	As^{74} (17.5)	Total body	0.56
		Lung (insol.)	0.38
		GI (S)	0.38
		GI (SI)	0.56
		GI (LI)	0.32
		Kidney	0.34
		Liver	0.38
33	As^{76} (1.11)	Total body	1.3
		Lung (insol.)	1.1
		GI (S)	1.1
		GI (SI)	1.3
		GI (LI)	1.1
		Kidney	1.1
		Liver	1.1
33	As^{77} (1.62)	Total body	0.24
		Lung (insol.)	0.24
		GI (S)	0.24
		GI (SI)	0.24
		GI (LI)	0.24
		Kidney	0.24
		Liver	0.24
38	Sr^{85m} (0.049) Sr^{85} (65) 86%	Total body	0.47
		Lung (insol.)	0.17
		Bone	0.13
38	Sr^{85m} (0.049) 14%	Total body	0.098
		Lung (insol.)	0.051
		GI (S)	0.051
		GI (SI)	0.098
		GI (LI)	0.034
		Bone	0.034
38	Sr^{85} (65)	Total body	0.33
		Lung (insol.)	0.16
		GI (S)	0.16
		GI (SI)	0.33
		GI (LI)	0.091
		Bone	0.091
38	Sr^{89} (50.5)	Total body	0.55
		Lung (insol.)	0.55
		GI (S)	0.55
		GI (SI)	0.55
		GI (LI)	0.55
		Bone	2.8
38	Sr^{90} (1.0×10^4) Y^{90} (2.68)	Total body	1.1
		Lung (insol.)	1.1
		Bone	5.5
38	Sr^{91} (0.40) + drs. 59%	Total body	1.9
		Lung (insol.)	1.2
		Bone	5.4
38	Sr^{91} (0.40) Y^{91} (58) 41%	Total body	2.4
		Lung (insol.)	2.0
		Bone	7.4

34	Sc^{75} (127)	Total body	0.20
		Lung (insol.)	0.094
		GI (S)	0.094
		GI (SI)	0.20
		GI (LI)	0.056
		Kidney	0.072
		Liver	0.094
		Spleen	0.072
35	Br^{82} (1.5)	Total body	1.8
		Lung (insol.)	0.85
		GI (S)	0.85
		GI (SI)	1.8
		GI (LI)	0.53
36	Kr^{85m} (0.18)	Submersion	0.44
36	Kr^{85} (3.9×10^3)	Submersion	0.24
36	Kr^{87} (0.054)	Submersion	2.8
37	Rb^{86} (18.6)	Total body	0.70
		Lung (insol.)	0.66
		GI (S)	0.66
		GI (SI)	0.70
		GI (LI)	0.65
		Pancreas	0.65
		Liver	0.66
		Spleen	0.66
		Muscle	0.70
37	Rb^{87} (1.8×10^{13})	Total body	0.090
		Lung (insol.)	0.090
		GI (S)	0.090
		GI (SI)	0.090
		GI (LI)	0.090
		Pancreas	0.090
		Liver	0.090
		Spleen	0.090
		Muscle	0.090
38	Sr^{92} (0.11) Y^{92} (0.15)	Total body	2.6
		Lung (insol.)	2.0
		Bone	8.0
39	Y^{90} (2.68)	Total body	0.89
		Lung (insol.)	0.89
		GI (S)	0.89
		GI (SI)	0.89
		GI (LI)	0.89
		Bone	4.4
39	Y^{91m} (0.035) Y^{91} (58)	Total body	0.93
		Lung (insol.)	0.55
		Bone	3.0
39	Y^{91} (58)	Total body	0.59
		Lung (insol.)	0.59
		GI (S)	0.59
		GI (SI)	0.59
		GI (LI)	0.59
		Bone	2.9
39	Y^{92} (0.15)	Total body	1.6
		Lung (insol.)	1.5
		GI (S)	1.5
		GI (SI)	1.6
		GI (LI)	1.4
		Bone	6.9
39	Y^{93} (0.42) + drs. (50%)	Total body	1.7
		Lung (insol.)	1.5
		Bone	6.5
39	Y^{93} (0.42) Zr^{93} (4.0×10^8) (50%)	Total body	1.7
		Lung (insol.)	1.5
		Bone	6.5
40	Zr^{93} (4.0×10^8) Nb^{93m}	Total body	0.024
		Lung (insol.)	0.020
		Bone	0.11

Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
	(3.7×10^3)	Kidney	0.024
		Spleen	0.025
		Liver	0.025
40	Zr^{93} 50 %	Total body	0.019
	(4.0×10^8)	Lung (insol.)	0.019
		GI (S)	0.019
		GI (SI)	0.019
		GI (LI)	0.019
		Bone	0.095
		Kidney	0.019
		Spleen	0.019
		Liver	0.019
40	Zr^{95}	Total body	1.1
	(63.3)	Lung (insol.)	0.52
	+ drs.	Kidney	0.46
		Spleen	0.46
		Liver	0.57
		Bone	1.1
40	Zr^{97}	Total body	2.1
	(0.71)	Lung (insol.)	1.6
	+ drs.	Bone	6.2
		Kidney	1.5
		Liver	1.6
		Spleen	1.5
41	Nb^{93m}	Total body	0.038
	(3.7×10^3)	Lung (insol.)	0.038
		GI (S)	0.038
		GI (SI)	0.038
		GI (LI)	0.038
		Bone	0.12
		Kidney	0.038
		Spleen	0.038
		Liver	0.038
41	Nb^{95}	Total body	0.51
		Liver	0.64
		Lung (sol.)	0.64
		Bone	0.35
		Skin	0.0083
43	Tc^{97m}	Total body	0.090
	(92)	Lung (insol.)	0.090
	Tc^{97}	Kidney	0.090
	(3.7×10^6)	Liver	0.090
		Skin	0.071
		Bone	0.37
		Lung (sol.)	0.090
43	Tc^{97}	Total body	0.020
	(3.7×10^6)	Lung (insol.)	0.020
		GI (S)	0.020
		GI (SI)	0.020
		GI (LI)	0.019
		Kidney	0.020
		Liver	0.020
		Bone	0.019
		Lung (sol.)	0.020
		Skin	0.0011
43	Tc^{99m}	Total body	0.080
	(0.25)	Lung (insol.)	0.035
	Tc^{99}	Kidney	0.026
	(7.3×10^7)	Lung (sol.)	0.035
		Liver	0.035
		Bone	0.020
		Skin	0.0022
43	Tc^{99}	Total body	0.094
	(7.3×10^7)	Lung (insol.)	0.094
		GI (S)	0.094
		GI (SI)	0.094
		GI (LI)	0.094
		Kidney	0.094
		Liver	0.094

	(35)	Lung (insol.)	0.26
		GI (S)	0.26
		GI (SI)	0.51
		GI (LI)	0.16
		Liver	0.26
		Kidney	0.20
		Bone	0.37
		Spleen	0.20
41	Nb^{97} (0.051)	Total body	0.87
		Lung (insol.)	0.64
		GI (S)	0.64
		GI (SI)	0.87
		GI (LI)	0.56
		Bone	2.4
		Kidney	0.60
		Liver	0.64
		Spleen	0.60
42	Mo^{99} (2.79) + drs. } 87%	Total body	0.51
		Lung (insol.)	0.49
		Kidney	0.48
		Liver	0.48
42	Mo^{99} (2.79) Tc^{99} (7.3×10^7) } 13%	Total body	0.71
		Lung (insol.)	0.40
		Kidney	0.34
		Liver	0.40
43	Tc^{96m} (0.036) Tc^{96} (4.3)	Total body	0.30
		Lung (insol.)	0.66
		Kidney	0.42
		Liver	0.60
		Lung (sol.)	0.38
		Bone	0.39
		Skin	0.021
43	Tc^{96} (4.3)	Total body	1.4
		Lung (insol.)	0.64
		GI (S)	0.64
		GI (SI)	1.4
		GI (LI)	0.35
		Kidney	0.47
		Skin	0.094
		Bone	0.47
		Lung (sol.)	0.094
44	Ru^{97} (2.8) + drs.	Total body	0.15
		Lung (insol.)	0.13
		Kidney	0.077
		Bone	0.13
44	Ru^{103} (41) Rh^{103m} (0.038)	Total body	0.44
		Lung (insol.)	0.27
		Kidney	0.22
		Bone	0.62
44	Ru^{105} (0.19) + drs.	Total body	1.2
		Lung (insol.)	0.91
		Kidney	0.84
		Bone	3.5
44	$Ru^{106} + Rh^{106}$ (365)	Total body	1.4
		Lung (insol.)	1.4
		GI (S)	1.4
		GI (SI)	1.4
		GI (LI)	1.3
		Kidney	1.3
		Bone	6.5
45	Rh^{103m} (0.038)	Total body	0.055
		Lung (insol.)	0.055
		GI (S)	0.055
		GI (SI)	0.055
		GI (LI)	0.053
		Kidney	0.054
		Spleen	0.054
		Liver	0.055
		Bone	0.19
45	Rh^{105} (1.52)	Total body	0.20
		Lung (insol.)	0.19
		GI (S)	0.19
		GI (SI)	0.20
		GI (LI)	0.19
		Kidney	0.19

Z	Radionuclide (T_r in days)	Organ of reference	ΣEF(RBE)n (E in MeV)
		Spleen	0.19
		Liver	0.19
		Bone	0.95
46	Pd^{103}	Total body	0.064
	(17)	Lung (insol.)	0.063
	Rh^{103m}	Kidney	0.061
	(0.038)	Spleen	0.061
		Liver	0.063
46	$Pd^{109} + Ag^{109m}$	Total body	0.42
	(0.57)	Lung (insol.)	0.42
		GI (S)	0.42
		GI (SI)	0.42
		GI (LI)	0.42
		Kidney	0.42
		Spleen	0.42
		Liver	0.42
47	Ag^{105}	Total body	0.63
	(40)	Lung (insol.)	0.29
		GI (S)	0.29
		GI (SI)	0.63
		GI (LI)	0.16
		Kidney	0.22
		Liver	0.29
		Bone	0.16
47	$Ag^{110m} + Ag^{110}$	Total body	1.7
	(270)	Lung (insol.)	0.84
		GI (S)	0.84
		GI (SI)	1.7
		GI (LI)	0.51
		Kidney	0.65
		Liver	0.84
		Bone	1.1
47	$Ag^{111} + Cd^{111m}$	Total body	0.40
	(7.5)	Lung (insol.)	0.38
		Kidney	0.93
		Spleen	0.93
		Liver	0.94
		Bone	4.5
		Skin	0.90
		Thyroid	0.92
49	In^{115m}	Total body	0.26
	(0.19)	Lung (insol.)	0.20
	In^{115}	Kidney	0.19
	(2.2×10^{17})	Spleen	0.19
		Liver	0.20
		Thyroid	0.16
		Bone	0.74
		Skin	0.14
49	In^{115}	Total body	0.17
	(2.2×10^{17})	Lung (insol.)	0.17
		GI (S)	0.17
		GI (SI)	0.17
		GI (LI)	0.17
		Kidney	0.17
		Spleen	0.17
		Liver	0.17
		Bone	0.85
		Skin	0.17
		Thyroid	0.17
50	Sn^{113}	Total body	0.32
	(112)	Lung (insol.)	0.23
	In^{113m}	Bone	0.70
	(0.073)	Prostate	0.16
		Liver	0.23
		Thyroid	0.16
50	Sn^{125} (9.5) + drs. (83%)	Total body	0.94
		Lung (insol.)	0.96
		Bone	4.8
		Prostate	0.94

		GI (S)	0.38
		GI (SI)	0.40
		GI (LI)	0.37
		Kidney	0.37
		Bone	1.8
		Liver	0.38
48	$Cd^{109} + Ag^{109m}$ (475)	Total body	0.11
		Lung (insol.)	0.10
		GI (S)	0.10
		GI (SI)	0.11
		GI (LI)	0.092
		Liver	0.10
		Kidney	0.098
48	Cd^{115m} (43) + drs.	Total body	0.61
		Lung (insol.)	0.61
		Liver	0.61
		Kidney	0.61
48	Cd^{115} (2.2) + drs.	Total body	0.71
		Lung (insol.)	0.58
		Liver	0.58
		Kidney	0.56
49	In^{113m} (0.073)	Total body	0.29
		Lung (insol.)	0.21
		GI (S)	0.21
		GI (SI)	0.29
		GI (LI)	0.17
		Kidney	0.19
		Spleen	0.19
		Liver	0.21
		Bone	0.68
		Skin	0.13
		Thyroid	0.16
49	$In^{114m} + In^{\cdot 14}$ (49)	Total body	0.97
		Lung (insol.)	0.94
		GI (S)	0.94
		GI (SI)	0.97
		GI (LI)	0.93
		Liver	0.94
		Thyroid	0.93
50	Sn^{125} (9.5) Sb^{125} (877) 17%	Total body	0.95
		Lung (insol.)	0.96
		Bone	4.7
		Prostate	0.93
		Liver	0.94
		Thyroid	0.93
51	Sb^{122} (2.8)	Total body	0.82
		Lung (insol.)	0.67
		GI (S)	0.67
		GI (SI)	0.82
		GI (LI)	0.61
		Lung (sol.)	0.67
		Bone	2.7
		Liver	0.67
		Thyroid	0.59
51	Sb^{124} (60)	Total body	1.6
		Lung (insol.)	0.92
		GI (S)	0.92
		GI (SI)	1.6
		GI (LI)	0.68
		Lung (sol.)	0.92
		Bone	2.3
		Liver	0.92
		Thyroid	0.57
51	Sb^{125} (877) Te^{125m} (58) 83%	Total body	0.34
		Lung (insol.)	0.26
		Lung (sol.)	0.23
		Bone	0.69
		Liver	0.23
		Thyroid	0.15
51	Sb^{125} (877) 17%	Total body	0.43
		Lung (insol.)	0.21
		GI (S)	0.21
		GI (SI)	0.43
		GI (LI)	0.13

Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
		Lung (sol.)	0.21
		Bone	0.28
		Liver	0.21
		Thyroid	0.095
52	Te^{125m}	Total body	0.15
	(58)	Lung (insol.)	0.14
		GI (S)	0.14
		GI (SI)	0.15
		GI (LI)	0.13
		Kidney	0.14
		Testis	0.11
		Spleen	0.14
		Liver	0.14
		Bone	0.51
		Thyroid	0.11
52	Te^{127m}	Total body	0.32
	(105)	Lung (insol.)	0.32
	Te^{127}	Kidney	0.32
	(0.39)	Testis	0.31
		Spleen	0.32
		Bone	1.5
		Liver	0.32
		Thyroid	0.30
52	Te^{127}	Total body	0.24
	(0.39)	Lung (insol.)	0.24
		GI (S)	0.24
		GI (SI)	0.24
		GI (LI)	0.24
		Kidney	0.24
		Testis	0.24
		Spleen	0.24
		Bone	1.2
		Liver	0.24
		Thyroid	0.24
53	I^{129}	Total body	0.089
	(6.3×10^9)	Lung (insol.)	0.082
		GI (S)	0.082
		GI (SI)	0.089
		GI (LI)	0.073
		Thyroid	0.068
53	$I^{131} + Xe^{131m}$	Total body	0.44
	(8.05)	Lung (insol.)	0.30
		GI (S)	0.30
		GI (SI)	0.44
		GI (LI)	0.25
		Thyroid	0.23
53	I^{132}	Total body	1.7
	(0.097)	Lung (insol.)	1.0
		GI (S)	1.0
		GI (SI)	1.7
		GI (LI)	0.76
		Thyroid	0.65
53	I^{133}	Total body	0.84
	(0.87)	Lung (insol.)	0.64
	+ drs.	Thyroid	0.54
53	I^{134}	Total body	1.5
	(0.036)	Lung (insol)	1.1
		GI (S)	1.1
		GI (SI)	1.5
		GI (LI)	0.90
		Thyroid	0.82
53	I^{135}	Total body	1.3
	(0.28)	Lung (insol.)	0.77
	+ drs.	Thyroid	0.52
54	Xe^{131m}	Submersion	0.16
	(12)		

52	Te^{129m} (33) + drs.	Total body	1.1
		Lung (insol.)	0.83
		Kidney	0.78
		Testis	0.69
		Spleen	0.78
		Liver	0.83
		Bone	3.2
		Thyroid	0.68
52	Te^{129} (0.051) I^{129} (6.3×10^9)	Total body	0.98
		Lung (insol.)	0.73
		Kidney	0.68
		Testis	0.60
		Spleen	0.68
		Liver	0.73
		Bone	2.8
		Thyroid	0.60
52	Te^{131m} (1.25) + drs.	Total body	1.6
		Lung (insol.)	1.0
		Kidney	0.81
		Spleen	0.80
		Liver	0.97
		Bone	2.6
		Thyroid	0.69
52	Te^{132} (3.2) I^{132} (0.097)	Total body	1.9
		Lung (insol.)	1.1
		Kidney	0.96
		Spleen	0.96
		Testis	0.73
		Bone	3.1
		Liver	1.1
		Thyroid	0.74
53	I^{126} (13.3)	Total body	0.23
		Lung (insol.)	0.18
		GI (S)	0.18
		GI (SI)	0.23
		GI (LI)	0.17
		Thyroid	0.16
54	Xe^{133} (5.27)	Submersion	0.19
54	Xe^{135} + Cs^{135m} (0.38)	Submersion	0.62
55	Cs^{131} (10)	Total body	0.029
		Lung (insol.)	0.024
		GI (S)	0.024
		GI (SI)	0.029
		GI (LI)	0.017
		Liver	0.024
		Spleen	0.021
		Kidney	0.021
		Muscle	0.029
		Bone	0.017
		Lung (sol.)	0.024
55	Cs^{134m} (0.13) Cs^{134} (840)	Total body	0.19
		Lung (insol.)	0.17
		Liver	0.15
		Spleen	0.13
		Kidney	0.11
		Muscle	0.26
		Bone	0.49
		Lung (sol.)	0.17
55	Cs^{134} (840)	Total body	1.1
		Lung (insol.)	0.57
		GI (S)	0.57
		GI (SI)	1.1
		GI (LI)	0.38
		Liver	0.57
		Muscle	1.1
		Spleen	0.46
		Kidney	0.46
		Lung (sol.)	0.57
		Bone	0.99
55	Cs^{135} (1.1×10^9)	Total body	0.066
		Lung (insol.)	0.066
		GI (S)	0.066
		GI (SI)	0.066

Z	Radionuclide (T_r in days)	Organ of reference	ΣEF(RBE)n (E in MeV)
		GI (LI)	0.066
		Liver	0.066
		Spleen	0.066
		Bone	0.33
		Muscle	0.066
		Kidney	0.066
		Lung (sol.)	0.066
55	Cs^{136} (13)	Total body	0.65
		Lung (insol.)	0.35
		GI (S)	0.35
		GI (SI)	0.65
		GI (LI)	0.24
		Liver	0.35
		Spleen	0.29
		Muscle	0.65
		Kidney	0.29
		Bone	0.72
		Lung (sol.)	0.35
55	$Cs^{137} + Ba^{137m}$ (1.1×10^4)	Total body	0.59
		Lung (insol.)	0.41
		GI (S)	0.41
		GI (SI)	0.59
		GI (LI)	0.24
		Liver	0.41
		Spleen	0.37
		Muscle	0.59
		Bone	1.4
		Kidney	0.37
		Lung (sol.)	0.41
56	Ba^{131} (11.6) Cs^{131} (10)	Total body	0.38
		Lung (insol.)	0.19
		Bone	0.11
		Liver	0.19
		Muscle	0.38
		Spleen	0.14
		Kidney	0.14
		Lung (sol.)	0.19
		Bone	3.9
		Liver	0.81
		Kidney	0.81
59	Pr^{143} (13.7)	Total body	0.32
		Lung (insol.)	0.32
		GI (S)	0.32
		GI (SI)	0.32
		GI (LI)	0.32
		Bone	1.6
		Liver	0.32
		Kidney	0.32
60	Nd^{144} (7.3×10^{17})	Total body	20
		Lung (insol.)	20
		GI (S)	0.19
		GI (SI)	0.19
		GI (LI)	0.19
		Bone	100
		Kidney	20
		Liver	20
60	Nd^{147} (11.3) + drs.	Total body	0.40
		Lung (insol.)	0.30
		Liver	0.32
		Kidney	0.31
		Bone	1.4
60	Nd^{149} (0.083) Pm^{149} (2.2)	Total body	1.1
		Lung (insol.)	0.99
		Liver	0.99
		Kidney	0.97
		Bone	4.7
61	Pm^{147} (920) Sm^{147} (4.8×10^{13})	Total body	0.069
		Lung (insol.)	0.069
		Bone	0.35
		Kidney	0.069
		Liver	0.069

56	Ba^{140} (12.8) La^{140} (1.68)	Total body	2.3
		Lung (insol.)	1.4
		Bone	4.2
		Liver	1.4
		Lung (sol.)	1.4
		Muscle	2.3
		Spleen	1.2
		Kidney	1.2
57	La^{140} (1.68)	Total body	1.9
		Lung (insol.)	1.1
		GI (S)	1.1
		GI (SI)	1.9
		GI (LI)	0.80
		Liver	1.1
		Bone	2.7
58	Ce^{141} (32)	Total body	0.21
		Lung (insol.)	0.18
		GI (S)	0.18
		GI (SI)	0.21
		GI (LI)	0.17
		Liver	0.18
		Bone	0.81
		Kidney	0.18
58	Ce^{143} (1.33) Pr^{143} (13.7)	Total body	0.97
		Lung (insol.)	0.83
		Liver	0.85
		Bone	3.8
		Kidney	0.82
58	Ce^{144} (290) + drs.	Total body	1.3
		Lung (insol.)	1.3
		Bone	6.3
		Liver	1.3
		Kidney	1.3
59	Pr^{142} (0.80)	Total body	0.85
		Lung (insol.)	0.81
		GI (S)	0.81
		GI (SI)	0.85
		GI (LI)	0.80
61	Pm^{149} (2.2)	Total body	0.54
		Lung (insol.)	0.44
		GI (S)	0.44
		GI (SI)	0.54
		GI (LI)	0.41
		Bone	1.9
		Kidney	0.42
		Liver	0.44
62	Sm^{147} (4.8×10^{13})	Total body	23
		Lung (insol.)	23
		GI (S)	0.22
		GI (SI)	0.22
		GI (LI)	0.22
		Bone	115
		Kidney	23
		Liver	23
62	Sm^{151} (3.7×10^{4})	Total body	0.042
		Lung (insol.)	0.042
		GI (S)	0.042
		GI (SI)	0.042
		GI (LI)	0.041
		Bone	0.13
		Kidney	0.042
		Liver	0.042
62	Sm^{153} (1.96)	Total body	0.30
		Lung (insol.)	0.26
		GI (S)	0.26
		GI (SI)	0.30
		GI (LI)	0.24
		Liver	0.26
		Bone	1.1
		Kidney	0.25
63	Eu^{152} (0.38)	Total body	0.88
		Lung (insol.)	0.71
		GI (S)	0.71
		GI (SI)	0.88
		GI (LI)	0.65
		Liver	0.71
		Bone	2.9
		Kidney	0.71

Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
63	Eu^{152} (4.7×10^3)	Total body	0.66
		Lung (insol.)	0.33
		GI (S)	0.33
		GI (SI)	0.66
		GI (LI)	0.20
		Kidney	0.25
		Bone	0.45
		Liver	0.33
63	Eu^{154} (5.8×10^3)	Total body	1.3
		Lung (insol.)	0.86
		GI (S)	0.86
		GI (SI)	1.3
		GI (LI)	0.69
		Kidney	0.76
		Bone	2.7
		Liver	0.86
63	Eu^{155} (621)	Total body	0.16
		Lung (insol.)	0.095
		GI (S)	0.095
		GI (SI)	0.16
		GI (LI)	0.075
		Kidney	0.083
		Bone	0.28
		Liver	0.095
64	$Gd^{153} + Eu^{153m}$ (236)	Total body	0.17
		Lung (insol.)	0.099
		GI (S)	0.099
		GI (SI)	0.17
		GI (LI)	0.072
		Bone	0.23
		Liver	0.099
64	Gd^{159} (0.75)	Total body	0.36
		Lung (insol.)	0.33
		GI (S)	0.33
		GI (SI)	0.36
68	Er^{171} (0.31) + drs.	Total body	0.65
		Lung (insol.)	0.49
		Bone	2.0
		Kidney	0.46
69	$Tm^{170} + Yb^{170m}$ (127)	Total body	0.34
		Lung (insol.)	0.34
		GI (S)	0.34
		GI (SI)	0.34
		GI (LI)	0.34
		Bone	1.7
		Kidney	0.34
69	Tm^{171} (694)	Total body	0.030
		Lung (insol.)	0.030
		GI (S)	0.030
		GI (SI)	0.030
		GI (LI)	0.030
		Bone	0.15
		Kidney	0.030
70	Yb^{175} (4.1)	Total body	0.16
		Lung (insol.)	0.15
		GI (S)	0.15
		GI (SI)	0.16
		GI (LI)	0.15
		Bone	0.71
		Kidney	0.15
71	Lu^{177} (6.7)	Total body	0.17
		Lung (insol.)	0.16
		GI (S)	0.16
		GI (SI)	0.17
		GI (LI)	0.16
		Bone	0.76
		Kidney	0.16
72	$Hf^{181} + Ta^{181m}$ (46)	Total body	0.50
		Lung (insol.)	0.29

		GI (LI)	0.32
		Bone	0.75
		Liver	0.33
65	$Tb^{160} + Dy^{160m}$ (73)	Total body	0.85
		Lung (insol.)	0.48
		GI (S)	0.48
		GI (SI)	0.85
		GI (LI)	0.34
		Bone	1.1
		Kidney	0.40
66	Dy^{165} (0.097)	Total body	0.51
		Lung (insol.)	0.39
		GI (S)	0.39
		GI (SI)	0.51
		GI (LI)	0.34
		Bone	1.5
		Liver	0.39
66	Dy^{166} (3.4) + drs.	Total body	0.79
		Lung (insol.)	0.75
		Bone	3.9
		Liver	0.78
67	$Ho^{166} + Er^{166m}$ (1.1)	Total body	0.70
		Lung (insol.)	0.69
		GI (S)	0.69
		GI (SI)	0.70
		GI (LI)	0.69
		Bone	3.4
		Kidney	0.69
		Liver	0.69
68	$Er^{169} + Tm^{169m}$ (9.4)	Total body	0.37
		Lung (insol.)	0.22
		GI (S)	0.22
		GI (SI)	0.37
		GI (LI)	0.17
		Bone	0.58
		Kidney	0.19
		Liver	0.22
		GI (S)	0.29
		GI (SI)	0.50
		GI (LI)	0.22
		Spleen	0.25
		Liver	0.29
		Kidney	0.25
		Bone	0.74
73	$Ta^{182} + W^{182m}$ (112)	Total body	1.1
		Lung (insol.)	0.56
		GI (S)	0.56
		GI (SI)	1.1
		GI (LI)	0.38
		Liver	0.56
		Kidney	0.45
		Spleen	0.45
		Bone	1.0
74	W^{181} (140)	Total body	0.20
		Lung (insol.)	0.087
		GI (S)	0.087
		GI (SI)	0.20
		GI (LI)	0.047
		Liver	0.087
		Bone	0.047
74	W^{185} (74)	Total body	0.14
		Lung (insol.)	0.14
		GI (S)	0.14
		GI (SI)	0.14
		GI (LI)	0.14
		Bone	0.68
		Liver	0.14
74	W^{187} (1) + drs.	Total body	0.68
		Lung (insol.)	0.44
		Liver	0.44
		Bone	1.4
75	Re^{183} (73)	Total body	0.24
		Lung (insol.)	0.10
		GI (S)	0.10
		GI (SI)	0.24

Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
		GI (LI)	0.055
		Thyroid	0.034
		Liver	0.10
		Skin	0.0012
		Bone	0.055
75	$Re^{186} + Os^{186m}$ (3.79)	Total body	0.38
		Lung (insol.)	0.37
		GI (S)	0.37
		GI (SI)	0.38
		GI (LI)	0.36
		Skin	0.36
		Thyroid	0.36
		Liver	0.37
		Bone	1.8
75	Re^{187} (1.8×10^{13})	Total body	0.012
		Lung (insol.)	0.012
		GI (S)	0.012
		GI (SI)	0.012
		GI (LI)	0.012
		Skin	0.012
		Thyroid	0.012
		Liver	0.012
		Bone	0.062
75	$Re^{188} + Os^{186m}$ (0.71)	Total body	0.94
		Lung (insol.)	0.85
		GI (S)	0.85
		GI (SI)	0.94
		GI (LI)	0.82
		Thyroid	0.80
		Skin	0.78
		Liver	0.85
		Bone	3.9
76	Os^{185} (95)	Total body	0.51
		Lung (insol.)	0.29
		GI (S)	0.29
77	Ir^{194} (0.79)	Total body	0.81
		Lung (Insol.)	0.81
		GI (S)	0.81
		GI (SI)	0.81
		GI (LI)	0.81
		Kidney	0.81
		Liver	0.81
		Spleen	0.81
78	Pt^{191} (3)	Total body	0.70
		Lung (insol.)	0.31
		GI (S)	0.31
		GI (SI)	0.70
		GI (LI)	0.16
		Kidney	0.22
		Liver	0.31
		Spleen	0.22
78	Pt^{193m} (3.5) Pt^{193} (1.8×10^5)	Total Body	0.075
		Lung (insol.)	0.032
		Kidney	0.023
		Liver	0.032
		Spleen	0.023
78	Pt^{193} (1.8×10^5)	Total body	0.043
		Lung (insol.)	0.019
		GI (S)	0.019
		GI (SI)	0.043
		GI (LI)	0.0099
		Kidney	0.014
		Spleen	0.014
		Liver	0.019
78	Pt^{197m} (0.056) Pt^{197} (0.75)	Total body	0.55
		Lung (insol.)	0.52
		Kidney	0.50
		Liver	0.51
		Spleen	0.50

		GI (SI)	0.51
		GI (LI)	0.23
		Kidney	0.25
		Liver	0.29
76	Os^{191m} (0.58) + drs.	Total body	0.060
		Lung (insol.)	0.13
		Kidney	0.039
		Liver	0.049
76	$Os^{191} + Ir^{191m}$ (16)	Total body	0.16
		Lung (insol.)	0.12
		GI (S)	0.12
		GI (SI)	0.16
		GI (LI)	0.10
		Kidney	0.11
		Liver	0.12
76	Os^{193} (1.31)	Total body	0.38
		Lung (insol.)	0.38
		GI (S)	0.38
		GI (SI)	0.38
		GI (LI)	0.38
		Kidney	0.38
		Liver	0.38
77	Ir^{190} (12)	Total body	0.37
		Lung (insol.)	0.16
		GI (S)	0.16
		GI (SI)	0.37
		GI (LI)	0.087
		Kidney	0.12
		Liver	0.16
		Spleen	0.12
77	Ir^{192} (74.5)	Total body	1.1
		Lung (insol.)	0.60
		GI (S)	0.60
		GI (SI)	1.1
		GI (LI)	0.42
		Kidney	0.50
		Spleen	0.50
		Liver	0.60
78	Pt^{197} (0.75)	Total body	0.26
		Lung (insol.)	0.24
		GI (S)	0.24
		GI (SI)	0.26
		GI (LI)	0.23
		Kidney	0.23
		Liver	0.24
		Spleen	0.23
79	Au^{196} (5.6)	Total body	0.46
		Lung (insol.)	0.21
		GI (S)	0.21
		GI (SI)	0.46
		GI (LI)	0.11
		Kidney	0.15
		Spleen	0.15
		Liver	0.21
79	Au^{198} (2.7)	Total body	0.58
		Lung (insol.)	0.44
		GI (S)	0.44
		GI (SI)	0.58
		GI (LI)	0.38
		Kidney	0.41
		Spleen	0.41
		Liver	0.44
79	$Au^{199} + Hg^{199m}$ (3.15)	Total body	0.18
		Lung (insol.)	0.13
		GI (S)	0.13
		GI (SI)	0.18
		GI (LI)	0.11
		Kidney	0.12
		Spleen	0.12
		Liver	0.13
80	Hg^{197m} (1) + drs.	Total body	0.30
		Lung (insol.)	0.20
		Kidney	0.18
		Spleen	0.17
		Liver	0.19

Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
80	Hg^{197}	Total body	0.097
	(2.7)	Lung (insol.)	0.052
		GI (S)	0.052
		GI (SI)	0.097
		GI (LI)	0.036
		Kidney	0.043
		Spleen	0.043
		Liver	0.052
80	Hg^{203}	Total body	0.25
	(45.8)	Lung (insol.)	0.17
		GI (S)	0.17
		GI (SI)	0.25
		GI (LI)	0.14
		Kidney	0.15
		Spleen	0.15
		Liver	0.17
81	Tl^{200}	Total body	0.40
	(1.13)	Lung (insol.)	0.18
		GI (S)	0.18
		GI (SI)	0.40
		GI (LI)	0.095
		Kidney	0.13
		Muscle	0.40
		Liver	0.18
		Lung (sol.)	0.18
		Bone	0.095
81	Tl^{201}	Total body	0.17
	(3)	Lung (insol.)	0.12
		GI (S)	0.12
		GI (SI)	0.17
		GI (LI)	0.10
		Kidney	0.11
		Muscle	0.17
		Liver	0.12
		Bone	0.44
		Lung (sol.)	0.12
83	$Bi^{206} + Pb^{206m}$	Total body	1.8
	(6.4)	Lung (insol.)	0.80
		GI (S)	0.80
		GI (SI)	1.8
		GI (LI)	0.43
		Kidney	0.58
		Liver	0.80
		Spleen	0.58
		Bone	0.43
83	$Bi^{207} + Pb^{207m}$	Total body	1.0
	(2.9×10^3)	Lung (insol.)	0.45
		GI (S)	0.45
		GI (SI)	1.0
		GI (LI)	0.24
		Kidney	0.33
		Liver	0.45
		Spleen	0.33
		Bone	0.24
83	Bi^{210}	Total body	10
	(5)	Lung (insol.)	26
	+ drs.	Kidney	19
		Bone	40
		Liver	13
		Spleen	17
83	Bi^{212}	Total body	83
	(0.042)	Lung (insol.)	83
	+ drs.	GI (S)	1.8
		GI (SI)	2.2
		GI (LI)	1.7
		Kidney	82
		Liver	83
		Spleen	82
		Bone	411
84	Po^{210}	Total body	55
	(138.4)	Lung (insol.)	55

81	Tl^{202} (12)	Total body	0.38
		Lung (insol.)	0.27
		GI (S)	0.27
		GI (SI)	0.38
		GI (LI)	0.23
		Kidney	0.24
		Muscle	0.38
		Liver	0.27
		Bone	0.94
		Lung (sol.)	0.27
81	Tl^{204} (1.1×10^3)	Total body	0.25
		Lung (insol.)	0.25
		GI (S)	0.25
		GI (SI)	0.25
		GI (LI)	0.25
		Kidney	0.25
		Bone	1.3
		Liver	0.25
		Muscle	0.25
		Lung (sol.)	0.25
82	Pb^{203} (2.17)	Total body	0.22
		Lung (insol.)	0.094
		GI (S)	0.094
		GI (SI)	0.22
		GI (LI)	0.051
		Kidney	0.069
		Liver	0.094
		Bone	0.051
82	Pb^{210} (7.1×10^3) + drs.	Total body	5.2
		Lung (insol.)	25
		Kidney	10
		Bone	29
		Liver	10
82	Pb^{212} (0.44) + drs.	Total body	82
		Lung (insol.)	83
		Kidney	81
		Bone	410
		Liver	83
		GI (S)	0.53
		GI (SI)	0.53
		GI (LI)	0.53
		Spleen	55
		Kidney	55
		Liver	55
		Bone	280
85	At^{211} (0.30) + drs. 41%	Total body	61
		Lung (insol.)	61
		Thyroid	61
		Ovary	61
		Spleen	61
85	$At^{211} + Po^{211}$ (0.30) 59%	Total body	77
		Lung (insol.)	77
		GI (S)	0.76
		GI (SI)	0.79
		GI (LI)	0.75
		Thyroid	77
		Ovary	77
		Spleen	77
88	Ra^{223} (11.7) + drs.	Total body	280
		Lung (insol.)	280
		GI (S)	3.7
		GI (SI)	3.8
		GI (LI)	3.7
		Bone	280
88	Ra^{224} (3.64) + drs.	Total body	280
		Lung (insol.)	280
		Bone	280
88	Ra^{226} (5.9×10^5) + drs.	Total body	110
		Bone	110
88	Ra^{228} (2.4×10^3) + drs.	Total body	230
		Lung (insol.)	160
		Bone	190
89	Ac^{227} (8.0×10^3)	Total body	200
		Lung (insol.)	230

Z	Radionuclide (T_r in days)	Organ of reference	ΣEF(RBE)n (E in MeV)
	+ drs.	Bone	1000
		Liver	62
		Kidney	62
89	Ac^{228}	Total body	230
	(0.26)	Lung (insol.)	160
	+ drs.	Bone	970
		Kidney	55
		Liver	56
90	Th^{227}	Total body	200
	(18.4)	Lung (insol.)	230
	+ drs.	Kidney	61
		Liver	61
		Bone	990
90	Th^{228}	Total body	230
	(7.0×10^2)	Lung (insol.)	240
	+ drs.	Bone	970
		Kidney	56
		Liver	56
90	Th^{230}	Total body	48
	(2.9×10^7)	Lung (insol.)	48
		GI (S)	0.47
		GI (SI)	0.47
		GI (LI)	0.47
		Bone	240
		Kidney	48
		Liver	48
90	Th^{231}	Total body	0.18
	(1.07)	Lung (insol.)	0.11
	Pa^{231}	Bone	0.56
	(1.3×10^7)	Kidney	0.14
		Liver	0.16
90	Th^{232}	Total body	62
	(5.1×10^{12})	Lung (insol.)	46
92	U^{232}	Total body	280
	(2.7×10^4)	Lung (insol.)	210
	+ drs.	Bone	1200
		Kidney	110
92	U^{233}	Total body	50
	(5.9×10^7)	Lung (insol.)	50
		GI (S)	0.49
		GI (SI)	0.49
		GI (LI)	0.49
		Kidney	50
		Bone	250
92	U^{234}	Total body	49
	(9.1×10^7)	Lung (insol.)	49
		GI (S)	0.48
		GI (SI)	0.49
		GI (LI)	0.48
		Kidney	49
		Bone	240
92	U^{235}	Total body	46
	(2.6×10^{11})	Lung (insol.)	46
	Th^{231}	Kidney	46
	(1.07)	Bone	230
92	U^{236}	Total body	47
	(8.7×10^9)	Lung (insol.)	47
		GI (S)	0.45
		GI (SI)	0.46
		GI (LI)	0.45
		Kidney	47
		Bone	230
92	U^{238}	Total body	43
	(1.6×10^{12})	Lung (insol.)	43
		GI (S)	0.43
		GI (SI)	0.43
		GI (LI)	0.43

	+ drs.	Bone	270
		Kidney	41
		Liver	41
90	Th^{234} + Pa^{234}	Total body	0.91
	(24.1)	Lung (insol.)	0.90
		GI (S)	0.90
		GI (SI)	0.91
		GI (LI)	0.90
		Bone	4.5
		Kidney	0.90
		Liver	0.90
91	Pa^{230} (17.7) + drs. (80%)	Total body	0.067
		Lung (insol.)	0.022
		Kidney	0.031
		Bone	0.11
91	Pa^{230} (17.7) + drs. (20%)	Total body	290
		Lung (insol.)	300
		Bone	1600
		Kidney	150
91	Pa^{231}	Total body	140
	(1.3×10^7)	Lung (insol.)	54
	+ drs.	Kidney	79
		Liver	63
		Bone	750
91	Pa^{233}	Total body	0.32
	(27.4)	Lung (insol.)	0.18
		GI (S)	0.18
		GI (SI)	0.32
		GI (LI)	0.13
		Kidney	0.15
		Bone	0.41
		Liver	0.18
92	U^{230}	Total body	350
	(20.8)	Lung (insol.)	350
	+ drs.	Kidney	350
		Bone	1800
		Kidney	43
		Bone	220
93	Np^{237}	Total body	49
	(8.0×10^8)	Lung (insol.)	49
	Pa^{233}	Bone	250
	(27.4)	Kidney	49
		Liver	49
93	Np^{239}	Total body	0.29
	(2.33)	Lung (insol.)	0.16
	+ drs.	Bone	0.98
		Kidney	0.21
		Liver	0.22
94	Pu^{238}	Total body	57
	(3.3×10^4)	Lung (insol.)	57
		GI (S)	0.55
		GI (SI)	0.55
		GI (LI)	0.55
		Bone	280
		Liver	57
		Kidney	57
94	Pu^{239}	Total body	53
	(8.9×10^6)	Lung (insol.)	53
		GI (S)	0.52
		GI (SI)	0.52
		GI (LI)	0.52
		Bone	270
		Liver	53
		Kidney	53
94	Pu^{240}	Total body	53
	(2.4×10^6)	Lung (insol.)	53
		GI (S)	0.52
		GI (SI)	0.52
		GI (LI)	0.52
		Bone	270
		Liver	53
		Kidney	53

Z	Radionuclide (T_r in days)	Organ of reference	$\Sigma EF(\mathrm{RBE})n$ (E in MeV)
94	Pu^{241}	Total body	2.3
	(4.8×10^3)	Lung (insol.)	0.053
	+ drs.	Bone	14
		Kidney	2.5
		Liver	1.0
94	Pu^{242}	Total body	51
	(1.4×10^8)	Lung (insol.)	51
		GI (S)	0.49
		GI (SI)	0.49
		GI (LI)	0.49
		Bone	250
		Liver	51
		Kidney	51
95	$Am^{241} + Np^{237m}$	Total body	57
	(1.7×10^5)	Lung (insol.)	57
		GI (S)	0.56
		GI (SI)	0.59
		GI (LI)	0.56
		Bone	280
		Kidney	57
		Liver	57
95	Am^{243}	Total body	54
	(2.9×10^6)	Lung (insol.)	54
	+ drs.	Bone	270
		Kidney	54
		Liver	54
96	Cm^{242}	Total body	80
	(162.5)	Lung (insol.)	64
	Pu^{238}	Liver	78
	(3.3×10^4)	Bone	400
		Kidney	78
96	Cm^{244}	Total body	60
	(6.7×10^3)	Lung (insol.)	60
	Pu^{240}	Bone	300
	(2.4×10^6)	Liver	60
		Kidney	60
96	Cm^{245}	Total body	56
	(7.3×10^6)	Lung (insol.)	55
	+ drs.	Bone	280
		Kidney	56
		Liver	56
96	Cm^{246}	Total body	56
	(2.4×10^6)	Lung (insol.)	56
		GI (S)	0.54
		GI (SI)	0.54
		GI (LI)	0.54
		Bone	280
		Kidney	56
		Liver	56
97	Bk^{249}	Total body	3.8
	(290)	Lung (insol.)	0.069
	Cf^{249}	Bone	20
	(1.7×10^5)		
98	Cf^{249}	Total body	60
	(1.7×10^5)	Lung (insol.)	60
		GI (S)	0.66
		GI (SI)	0.76
		GI (LI)	0.63
		Bone	300
98	Cf^{250}	Total body	62
	(3.7×10^3)	Lung (insol.)	62
	Cm^{246}	Bone	310
	(2.4×10^6)		

96	Cm^{243} (1.3×10^4) + drs.	Total body	60	98	Cf^{252} (804)	Total body	210
		Lung (insol.)	60			Lung (insol.)	210
		Bone	300			GI (S)	2.1
		Liver	60			GI (SI)	2.1
		Kidney	60			GI (LI)	2.1
						Bone	1100

Table 5a. Effective energies for chains

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract*		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
$_{20}Ca^{47}$	4.9	Total body	1.2	1.0	1.2	0.61	1.2	0.48
		Lung (insol.)	0.61	1.0	0.61			
		Bone	1.8	1.0	1.8			
Sc^{47}	3.43	Total body	0.26	0.90	0.23	0.21	0.26	0.19
		Lung (insol.)	0.21	0.97	0.20			
		Bone	0.89	0.91	0.81			
		Total body	Totals for Chain		1.4			
		Lung (insol.)			0.81			
		Bone			2.6			
$_{27}Co^{58m}$	0.38	Total body	0.026	1.0	0.026	0.024	0.026	0.019
		Lung (insol.)	0.024	1.0	0.024			
		Pancreas	0.019	1.0	0.019			
		Liver	0.024	1.0	0.024			
		Spleen	0.022	1.0	0.022			
		Kidney	0.022	1.0	0.022			
Co^{58}	72	Total body	0.61	0.12	0.073	0.29	0.61	0.17
		Lung (insol.)	0.29	0.63	0.18			
		Pancreas	0.17	0.12	0.020			
		Liver	0.29	0.12	0.035			
		Spleen	0.22	0.12	0.026			
		Kidney	0.22	0.12	0.026			
		Total body	Totals for Chain		0.099			
		Lung (insol.)			0.20			
		Pancreas			0.039			
		Liver			0.059			
		Spleen			0.048			
		Kidney			0.048			
$_{30}Zn^{69m}$	0.58	Total body	0.27	1.0	0.27	0.13	0.27	0.081
		Lung (insol.)	0.13	1.0	0.13			
		Prostate	0.057	1.0	0.057			
		Pancreas	0.081	1.0	0.081			
		Liver	0.13	1.0	0.13			
		Kidney	0.10	1.0	0.10			
		Ovary	0.057	1.0	0.057			
		Testis	0.057	1.0	0.057			
		Bone	0.16	1.0	0.16			
		Muscle	0.27	1.0	0.27			

* The abbreviations GI, S, SI and LI refer to gastrointestinal tract, stomach, small intestine, and large intestine (either upper or lower large intestine), respectively.

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Zn^{69}	0.036	Total body	0.37	1.0	0.37	0.37	0.37	0.37
		Lung (insol.)	0.37	1.0	0.37			
		Prostate	0.37	1.0	0.37			
		Pancreas	0.37	1.0	0.37			
		Liver	0.37	1.0	0.37			
		Kidney	0.37	1.0	0.37			
		Ovary	0.37	1.0	0.37			
		Testis	0.37	1.0	0.37			
		Bone	1.9	1.0	1.9			
		Muscle	0.37	1.0	0.37			
		Total body	Totals for Chain		0.64			
		Lung (insol.)			0.50			
		Prostate			0.43			
		Pancreas			0.45			
		Liver			0.50			
		Kidney			0.47			
		Ovary			0.43			
		Testis			0.43			
		Bone			2.1			
		Muscle			0.64			
$_{38}Sr^{85m}$ } 86%	0.049	Total body	0.14	1.0	0.14	0.066	0.14	0.039
		Lung (insol.)	0.066	1.0	0.066			
		Bone	0.039	1.0	0.039			
Sr^{85} } 86%	65	Total body	0.33	1.0	0.33	0.16	0.33	0.091
		Lung (insol.)	0.16	0.65	0.10			
		Bone	0.091	1.0	0.091			
		Total body	Totals for Chain		0.47			
		Lung (insol.)			0.17			
		Bone			0.13			
$_{38}Sr^{90}$	1.0×10^4	Total body	0.21	1.0	0.21	0.21	0.21	0.21
		Lung (insol.)	0.21	1.0	0.21			
		Bone	1.1	1.0	1.1			
Y^{90}	2.68	Total body	0.89	1.0	0.89	0.89	0.89	0.89
		Lung (insol.)	0.89	0.98	0.87			
		Bone	4.4	1.0	4.4			
		Total body	Totals for Chain		1.1			
		Lung (insol.)			1.1			
		Bone			5.5			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
$_{38}Sr^{91}$ } 59%	0.40	Total body	0.98	1.0	0.98	0.68	0.98	0.58
		Lung (insol.)	0.68	1.0	0.68			
		Bone	2.4	1.0	2.4			
Y^{91m} } 59%	0.035	Total body	0.34	1.0	0.34	0.15	0.34	0.082
		Lung (insol.)	0.15	1.0	0.15			
		Bone	0.082	1.0	0.082			
Y^{91} } 59%	58	Total body	0.59	1.0	0.59	0.59	0.59	0.59
		Lung (insol.)	0.59	0.67	0.40			
		Bone	2.9	1.0	2.9			
		Total body	Totals for Chain		1.9			
		Lung (insol.)			1.2			
		Bone			5.4			
$_{38}Sr^{91}$ } 41%	0.40	Total body	1.8	1.0	1.8	1.6	1.8	0.97
		Lung (insol.)	1.6	1.0	1.6			
		Bone	4.5	1.0	4.5			
Y^{91} } 41%	58	Total body	0.59	1.0	0.59	0.59	0.59	0.59
		Lung (insol.)	0.59	0.67	0.40			
		Bone	2.9	1.0	2.9			
		Total body	Totals for Chain		2.4			
		Lung (insol.)			2.0			
		Bone			7.4			
$_{38}Sr^{92}$	0.11	Total body	0.96	1.0	0.96	0.45	0.96	0.37
		Lung (insol.)	0.45	1.0	0.45			
		Bone	1.1	1.0	1.1			
Y^{92}	0.15	Total body	1.6	1.0	1.6	1.5	1.6	1.4
		Lung (insol.)	1.5	1.0	1.5			
		Bone	6.9	1.0	6.9			
		Total body	Totals for Chain		2.6			
		Lung (insol.)			2.0			
		Bone			8.0			
$_{39}Y^{91m}$	0.035	Total body	0.34	1.0	0.34	0.15	0.34	0.082
		Lung (insol.)	0.15	1.0	0.15			
		Bone	0.082	1.0	0.082			
Y^{91}	58	Total body	0.59	1.0	0.59	0.59	0.59	0.59
		Lung (insol.)	0.59	0.67	0.40			
		Bone	2.9	1.0	2.9			
		Total body	Totals for Chain		0.93			
		Lung (insol.)			0.55			
		Bone			3.0			

Radionuclide	Half-life (T, in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
$_{39}Y^{93}$	0.42	Total body	1.7	1.0	1.7	1.5	1.7	1.4
		Lung (insol.)	1.5	1.0	1.5			
		Bone	6.5	1.0	6.5			
Zr^{93} 50%	4.0×10^8	Total body	0.019	1.1×10^{-6}	2.1×10^{-8}	0.019	0.019	0.019
		Lung (insol.)	0.019	3.0×10^{-7}	5.7×10^{-9}			
		Bone	0.095	2.5×10^{-6}	2.4×10^{-7}			
Nb^{93m}	3.7×10^3	Total body	0.038	1.9×10^{-7}	7.2×10^{-9}	0.038	0.038	0.038
		Lung (insol.)	0.038	9.4×10^{-9}	3.6×10^{-10}			
		Bone	0.12	5.3×10^{-7}	6.4×10^{-8}			
		Total body	Totals for Chain		1.7			
		Lung (insol.)			1.5			
		Bone			6.5			
$_{39}Y^{93}$	0.42	Total body	1.7	1.0	1.7	1.5	1.7	1.4
		Lung (insol.)	1.5	1.0	1.5			
		Bone	6.5	1.0	6.5			
50%								
Zr^{93}	4.0×10^8	Total body	0.019	1.1×10^{-6}	2.1×10^{-8}	0.019	0.019	0.019
		Lung (insol.)	0.019	3.0×10^{-7}	5.7×10^{-9}			
		Bone	0.095	2.5×10^{-6}	2.4×10^{-7}			
		Total body	Totals for Chain		1.7			
		Lung (insol.)			1.5			
		Bone			6.5			
$_{40}Zr^{93}$	4.0×10^8	Total body	0.019	1.0	0.019	0.019	0.019	0.019
		Lung (insol.)	0.019	1.0	0.019			
		Bone	0.095	1.0	0.095			
		Kidney	0.019	1.0	0.019			
		Spleen	0.019	1.0	0.019			
		Liver	0.019	1.0	0.019			
Nb^{93m}	3.7×10^3	Total body	0.030	0.17	0.0051			
		Lung (insol.)	0.030	0.031	9.3×10^{-4}	0.030	0.030	0.030
		Bone	0.078	0.21	0.016			
		Kidney	0.030	0.17	0.0051			
		Spleen	0.030	0.20	0.0060			
		Liver	0.030	0.19	0.0057			
		Total body	Totals for Chain		0.024			
		Lung (insol.)			0.020			
		Bone			0.11			
		Kidney			0.024			
		Spleen			0.025			
		Liver			0.025			
$_{40}Zr^{95}$	63.3	Total body	0.57	1.0	0.57	0.32	0.57	0.24
Nb^{95m}		Lung (insol.)	0.32	1.0	0.32			
		Bone	0.77	1.0	0.77			

Radionuclide	Half-life (T, in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Nb^{95}	35	Kidney	0.27	1.0	0.27	0.26	0.51	0.16
		Liver	0.32	1.0	0.32			
		Spleen	0.27	1.0	0.27			
		Total body	0.51	0.96	0.49			
		Lung (insol.)	0.26	0.77	0.20			
		Bone	0.37	0.97	0.36			
		Kidney	0.20	0.96	0.19			
		Liver	0.26	0.96	0.25			
		Spleen	0.20	0.97	0.19			
		Total body	Totals for Chain		1.1			
		Lung (insol.)			0.52			
		Bone			1.1			
		Kidney			0.46			
		Liver			0.57			
		Spleen			0.46			
$_{40}Zr^{97}$ Nb^{97m}	0.71	Total body	1.2	1.0	1.2	0.94	1.2	0.85
		Lung (insol.)	0.94	1.0	0.94			
		Bone	3.8	1.0	3.8			
		Kidney	0.88	1.0	0.88			
		Liver	0.94	1.0	0.94			
		Spleen	0.88	1.0	0.88			
Nb^{97}	0.051	Total body	0.87	1.0	0.87	0.64	0.87	0.56
		Lung (insol.)	0.64	1.0	0.64			
		Bone	2.4	1.0	2.4			
		Kidney	0.60	1.0	0.60			
		Liver	0.64	1.0	0.64			
		Spleen	0.60	1.0	0.60			
		Total body	Totals for Chain		2.1			
		Lung (insol.)			1.6			
		Bone			6.2			
		Kidney			1.5			
		Liver			1.6			
		Spleen			1.5			
$_{42}Mo^{99}$	2.79	Total body	0.45	1.0	0.45	0.45	0.45	0.45
		Lung (insol.)	0.45	1.0	0.45			
		Kidney	0.45	1.0	0.45			
		Liver	0.45	1.0	0.45			
Tc^{99m} 87 %	0.25	Total body	0.080	0.80	0.064	0.035	0.080	0.020
		Lung (insol.)	0.035	1.0	0.035			
		Kidney	0.026	0.99	0.026			
		Liver	0.035	0.99	0.035			
Tc^{99}	7.3×10^7	Total body	0.094	10^{-8}	9.4×10^{-10}	0.094	0.094	0.094
		Lung (insol.)	0.094	1.6×10^{-6}	1.5×10^{-7}			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Kidney	0.094	2.6×10^{-7}	2.4×10^{-8}			
		Liver	0.094	3.9×10^{-7}	3.7×10^{-8}			
		Total body	Totals for Chain		0.51			
		Lung (insol.)			0.49			
		Kidney			0.48			
		Liver			0.48			
$_{42}Mo^{99}$	2.79	Total body	0.71	1.0	0.71	0.40	0.71	0.29
		Lung (insol.)	0.40	1.0	0.40			
13%		Kidney	0.34	1.0	0.34			
		Liver	0.40	1.0	0.40			
Tc^{99}	7.3×10^7	Total body	0.094	1.3×10^{-8}	1.2×10^{-9}	0.094	0.094	0.094
		Lung (insol.)	0.094	1.6×10^{-6}	1.5×10^{-7}			
		Kidney	0.094	2.6×10^{-7}	2.4×10^{-8}			
		Liver	0.094	3.9×10^{-7}	3.7×10^{-8}			
		Total body	Totals for Chain		0.71			
		Lung (insol.)			0.40			
		Kidney			0.34			
		Liver			0.40			
$_{43}Tc^{98m}$	0.036	Total body	0.034	1.0	0.034	0.034	0.034	0.032
		Lung (insol.)	0.034	1.0	0.034			
		Kidney	0.034	1.0	0.034			
		Liver	0.034	1.0	0.034			
		Lung (sol.)	0.034	1.0	0.034			
		Bone	0.089	1.0	0.089			
		Skin	0.015	1.0	0.015			
Tc^{96}	4.3	Total body	1.4	0.19	0.27	0.64	1.4	0.35
		Lung (insol.)	0.64	0.98	0.63			
		Kidney	0.47	0.81	0.38			
		Liver	0.64	0.88	0.56			
		Lung (sol.)	0.64	0.54	0.35			
		Bone	0.35	0.86	0.30			
		Skin	0.0083	0.70	0.0058			
		Total Body	Totals for Chain		0.30			
		Lung (insol.)			0.66			
		Kidney			0.42			
		Liver			0.60			
		Lung (sol.)			0.38			
		Bone			0.39			
		Skin			0.021			
$_{43}Tc^{97m}$	92	Total body	0.090	1.0	0.090	0.090	0.090	0.089
		Lung (insol.)	0.090	1.0	0.090			

Radionuclide	Half-life (T, in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Tc^{97}	3.7×10^6	Kidney	0.090	1.0	0.090	0.020	0.020	0.019
		Liver	0.090	1.0	0.090			
		Skin	0.071	1.0	0.071			
		Bone	0.37	1.0	0.37			
		Lung (sol.)	0.090	1.0	0.090			
		Total body	0.020	2.7×10^{-7}	5.4×10^{-9}			
		Lung (insol.)	0.020	3.2×10^{-5}	6.4×10^{-7}			
		Kidney	0.020	5.4×10^{-6}	1.1×10^{-7}			
		Liver	0.020	8.1×10^{-6}	1.6×10^{-7}			
		Skin	0.0011	2.7×10^{-6}	3.0×10^{-9}			
		Bone	0.019	6.8×10^{-6}	1.3×10^{-7}			
		Lung (sol.)	0.020	1.4×10^{-6}	2.8×10^{-8}			
		Total body	Totals for Chain		0.090			
		Lung (insol.)			0.090			
		Kidney			0.090			
		Liver			0.090			
		Skin			0.071			
		Bone			0.37			
		Lung (sol.)			0.090			
$_{43}Tc^{99m}$	0.25	Total body	0.080	1.0	0.080	0.035	0.080	0.020
		Lung (insol.)	0.035	1.0	0.035			
		Kidney	0.026	1.0	0.026			
		Lung (sol.)	0.035	1.0	0.035			
		Liver	0.035	1.0	0.035			
		Bone	0.020	1.0	0.020			
		Skin	0.0022	1.0	0.0022			
Tc^{99}	7.3×10^7	Total body	0.094	1.3×10^{-8}	1.2×10^{-9}	0.094	0.094	0.094
		Lung (insol.)	0.094	1.6×10^{-6}	1.5×10^{-7}			
		Kidney	0.094	2.6×10^{-7}	2.4×10^{-8}			
		Lung (sol.)	0.094	6.5×10^{-8}	6.1×10^{-9}			
		Liver	0.094	3.9×10^{-7}	3.7×10^{-8}			
		Bone	0.47	3.2×10^{-7}	1.5×10^{-7}			
		Skin	0.094	1.3×10^{-7}	1.2×10^{-8}			
		Total body	Totals for Chain		0.080			
		Lung (insol.)			0.035			
		Kidney			0.026			
		Lung (sol.)			0.035			
		Liver			0.035			
		Bone			0.020			
		Skin			0.0022			
$_{44}Ru^{97}$	2.8	Total body	0.15	1.0	0.15	0.078	0.15	0.050
		Lung (insol.)	0.078	1.0	0.078			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Kidney	0.062	1.0	0.062			
		Bone	0.050	1.0	0.050			
Tc^{97m}	92	Total body	0.090	0.011	9.9×10^{-4}	0.090	0.090	0.089
		Lung (insol.)	0.090	0.57	0.051			
		Kidney	0.090	0.17	0.015			
		Bone	0.37	0.22	0.081			
Tc^{97}	3.7×10^6	Total body	0.020	2.9×10^{-9}	5.8×10^{-11}	0.020	0.020	0.019
		Lung (insol.)	0.020	1.8×10^{-5}	3.6×10^{-7}			
		Kidney	0.020	9.4×10^{-7}	1.9×10^{-8}			
		Bone	0.019	1.5×10^{-6}	2.9×10^{-8}			
		Total body	Totals for Chain		0.15			
		Lung (insol.)			0.13			
		Kidney			0.077			
		Bone			0.13			
$_{44}Ru^{103}$	41	Total body	0.38	1.0	0.38	0.21	0.38	0.14
		Lung (insol.)	0.21	1.0	0.21			
		Kidney	0.17	1.0	0.17			
		Bone	0.43	1.0	0.43			
Rh^{103m}	0.038	Total body	0.055	1.0	0.055	0.055	0.055	0.053
		Lung (insol.)	0.055	1.0	0.055			
		Kidney	0.054	1.0	0.054			
		Bone	0.19	1.0	0.19			
		Total body	Totals for Chain		0.44			
		Lung (insol.)			0.27			
		Kidney			0.22			
		Bone			0.62			
$_{44}Ru^{105}$	0.19	Total body	0.98	1.0	0.98	0.72	0.98	0.62
Rh^{105m}		Lung (insol.)	0.72	1.0	0.72			
		Kidney	0.66	1.0	0.66			
		Bone	2.6	1.0	2.6			
Rh^{105}	1.52	Total body	0.20	0.88	0.18	0.19	0.20	0.19
		Lung (insol.)	0.19	0.99	0.19			
		Kidney	0.19	0.95	0.18			
		Bone	0.95	0.91	0.86			
		Total body	Totals for Chain		1.2			
		Lung (insol.)			0.91			
		Kidney			0.84			
		Bone			3.5			
$_{46}Pd^{103}$	17	Total body	0.023	1.0	0.023	0.022	0.023	0.019
		Lung (insol.)	0.022	1.0	0.022			
		Kidney	0.021	1.0	0.021			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Rh^{103m}	0.038	Spleen	0.021	1.0	0.021	0.041	0.041	0.039
		Liver	0.022	1.0	0.022			
		Total body	0.041	1.0	0.041			
		Lung (insol.)	0.041	1.0	0.041			
		Kidney	0.040	1.0	0.040			
		Spleen	0.040	1.0	0.040			
		Liver	0.041	1.0	0.041			
		Total body	Totals for Chain		0.064			
		Lung (insol.)			0.063			
		Kidney			0.061			
		Spleen			0.061			
		Liver			0.063			
$_{48}Cd^{115m}$	43	Total body	0.61	1.0	0.61	0.61	0.61	0.61
		Lung (insol.)	0.61	1.0	0.61			
		Liver	0.61	1.0	0.61			
		Kidney	0.61	1.0	0.61			
Cd^{115}	2.2	Total body	0	1.0	0	0	0	0
		Lung (insol.)	0	1.0	0			
		Liver	0	1.0	0			
		Kidney	0	1.0	0			
In^{115m}	0.19	Total body	0	0.99	0	0	0	0
		Lung (insol.)	0	1.0	0			
		Liver	0	0.99	0			
		Kidney	0	0.99	0			
In^{115}	2.2×10^{17}	Total body	0.17	2.2×10^{-16}	3.7×10^{-17}	0.17	0.17	0.17
		Lung (insol.)	0.17	5.5×10^{-16}	9.4×10^{-17}			
		Liver	0.17	2.6×10^{-16}	4.4×10^{-17}			
		Kidney	0.17	2.7×10^{-16}	4.6×10^{-17}			
		Total body	Totals for Chain		0.61			
		Lung (insol.)			0.61			
		Liver			0.61			
		Kidney			0.61			
$_{48}Cd^{115}$	2.2	Total body	0.45	1.0	0.45	0.38	0.45	0.36
		Lung (insol.)	0.38	1.0	0.38			
		Liver	0.38	1.0	0.38			
		Kidney	0.37	1.0	0.37			
In^{115m}	0.19	Total body	0.26	1.0	0.26	0.20	0.26	0.18
		Lung (insol.)	0.20	1.0	0.20			
		Liver	0.20	1.0	0.20			
		Kidney	0.19	1.0	0.19			
In^{115}	2.2×10^{17}	Total body	0.17	2.2×10^{-16}	3.7×10^{-17}	0.17	0.17	0.17
		Lung (insol.)	0.17	5.5×10^{-16}	9.4×10^{-17}			
		Liver	0.17	2.6×10^{-16}	4.4×10^{-17}			

Radionuclide	Half-life (T, in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Kidney	0.17	2.7×10^{-16}	4.6×10^{-17}			
		Total body	Totals for Chain		0.71			
		Lung (insol.)			0.58			
		Liver			0.58			
		Kidney			0.56			
$_{49}In^{115m}$	0.19	Total body	0.26	1.0	0.26	0.20	0.26	0.18
		Lung (insol.)	0.20	1.0	0.20			
		Kidney	0.19	1.0	0.19			
		Spleen	0.19	1.0	0.19			
		Liver	0.20	1.0	0.20			
		Thyroid	0.16	1.0	0.16			
		Bone	0.74	1.0	0.74			
		Skin	0.14	1.0	0.14			
In^{115}	2.2×10^{17}	Total body	0.17	2.2×10^{-16}	3.7×10^{-17}	0.17	0.17	0.17
		Lung (insol.)	0.17	5.5×10^{-16}	9.4×10^{-17}			
		Kidney	0.17	2.7×10^{-16}	4.6×10^{-17}			
		Spleen	0.17	2.2×10^{-16}	3.7×10^{-17}			
		Liver	0.17	2.6×10^{-16}	4.4×10^{-17}			
		Thyroid	0.17	3.8×10^{-17}	6.5×10^{-17}			
		Bone	0.85	2.6×10^{-16}	2.2×10^{-16}			
		Skin	0.17	3.0×10^{-16}	5.1×10^{-17}			
		Total body	Totals for Chain		0.26			
		Lung (insol.)			0.20			
		Kidney			0.19			
		Spleen			0.19			
		Liver			0.20			
		Thyroid			0.16			
		Bone			0.74			
		Skin			0.14			
$_{50}Sn^{113}$	112	Total body	0.028	1.0	0.028	0.024	0.028	0.018
		Lung (insol.)	0.024	1.0	0.024			
		Bone	0.018	1.0	0.018			
		Prostate	0.0023	1.0	0.0023			
		Liver	0.024	1.0	0.024			
		Thyroid	0.0023	1.0	0.0023			
In^{113m}	0.073	Total body	0.29	1.0	0.29	0.21	0.29	0.17
		Lung (insol.)	0.21	1.0	0.21			
		Bone	0.68	1.0	0.68			
		Prostate	0.16	1.0	0.16			
		Liver	0.21	1.0	0.21			
		Thyroid	0.16	0.99	0.16			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Total body			0.32			
		Lung (insol.)			0.23			
		Bone	Totals for Chain		0.70			
		Prostate			0.16			
		Liver			0.23			
		Thyroid			0.16			
$_{50}Sn^{125}$	9.5	Total body	0.93	1.0	0.93	0.93	0.93	0.93
		Lung (insol.)	0.93	1.0	0.93			
		Bone	4.7	1.0	4.7			
		Prostate	0.93	1.0	0.93			
		Liver	0.93	1.0	0.93			
		Thyroid	0.93	1.0	0.93			
Sb^{125} 83%	877	Total body	0.32	0.041	0.013	0.21	0.32	0.16
		Lung (insol.)	0.21	0.12	0.025			
		Bone	0.62	0.10	0.062			
		Prostate	0.14	0.041	0.0057			
		Liver	0.21	0.042	0.0088			
		Thyroid	0.14	0.0046	6.4×10^{-4}			
Te^{125m}	58	Total body	0.075	0.0085	6.4×10^{-4}	0.070	0.075	0.061
		Lung (insol.)	0.070	0.081	0.0057			
		Bone	0.21	0.035	0.0074			
		Prostate	0.055	0.0085	4.7×10^{-4}			
		Liver	0.070	0.014	9.8×10^{-4}			
		Thyroid	0.055	6.1×10^{-4}	3.4×10^{-5}			
		Total body			0.94			
		Lung (insol.)			0.96			
		Bone	Totals for Chain		4.8			
		Prostate			0.94			
		Liver			0.94			
		Thyroid			0.93			
$_{50}Sn^{125}$	9.5	Total body	0.93	1.0	0.93	0.93	0.93	0.93
		Lung (insol.)	0.93	1.0	0.93			
		Bone	4.7	1.0	4.7			
17%		Prostate	0.93	1.0	0.93			
		Liver	0.93	1.0	0.93			
		Thyroid	0.93	1.0	0.93			
Sb^{125}	877	Total body	0.43	0.041	0.018	0.21	0.43	0.13
		Lung (insol.)	0.21	0.12	0.025			
		Bone	0.28	0.10	0.028			
		Prostate	0.095	0.041	0.0039			
		Liver	0.21	0.042	0.0088			
		Thyroid	0.095	0.0046	4.4×10^{-4}			

Radionuclide	Half-life (T_r, in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Total body	Totals for Chain		0.95			
		Lung (insol.)			0.96			
		Bone			4.7			
		Prostate			0.93			
		Liver			0.94			
		Thyroid			0.93			
$_{51}Sb^{125}$	877	Total body	0.32	1.0	0.32	0.21	0.32	0.16
		Lung (insol.)	0.21	1.0	0.21			
		Lung (sol.)	0.21	1.0	0.21			
83%		Bone	0.62	1.0	0.62			
		Liver	0.21	1.0	0.21			
		Thyroid	0.14	1.0	0.14			
Te^{125m}	58	Total body	0.075	0.21	0.016	0.070	0.075	0.061
		Lung (insol.)	0.070	0.67	0.047			
		Lung (sol.)	0.070	0.31	0.022			
		Bone	0.21	0.34	0.071			
		Liver	0.070	0.34	0.024			
		Thyroid	0.055	0.13	0.0072			
		Total body	Totals for Chain		0.34			
		Lung (insol.)			0.26			
		Lung (sol.)			0.23			
		Bone			0.69			
		Liver			0.23			
		Thyroid			0.15			
$_{52}Te^{127m}$	105	Total body	0.089	1.0	0.089	0.083	0.089	0.076
		Lung (insol.)	0.083	1.0	0.083			
		Kidney	0.079	1.0	0.079			
		Testis	0.070	1.0	0.070			
		Spleen	0.079	1.0	0.079			
		Bone	0.31	1.0	0.31			
		Liver	0.083	1.0	0.083			
		Thyroid	0.070	1.0	0.070			
Te^{127}	0.39	Total body	0.24	0.97	0.23	0.24	0.24	0.24
		Lung (insol.)	0.24	1.0	0.24			
		Kidney	0.24	0.99	0.24			
		Testis	0.24	0.99	0.24			
		Spleen	0.24	0.99	0.24			
		Bone	1.2	0.99	1.2			
		Liver	0.24	0.99	0.24			
		Thyroid	0.24	0.95	0.23			
		Total body	Totals for Chain		0.32			
		Lung (insol.)			0.32			
		Kidney			0.32			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Testis			0.31			
		Spleen			0.32			
		Bone	Totals for Chain		1.5			
		Liver			0.32			
		Thyroid			0.30			
$_{52}Te^{129m}$	33	Total body	0.11	1.0	0.11	0.10	0.11	0.093
		Lung (insol.)	0.10	1.0	0.10			
		Kidney	0.096	1.0	0.096			
		Testis	0.087	1.0	0.087			
		Spleen	0.096	1.0	0.096			
		Liver	0.10	1.0	0.10			
		Bone	0.40	1.0	0.40			
		Thyroid	0.087	1.0	0.087			
Te^{129}	0.051	Total body	0.98	1.0	0.98	0.73	0.98	0.64
		Lung (insol.)	0.73	1.0	0.73			
		Kidney	0.68	1.0	0.68			
		Testis	0.60	1.0	0.60			
		Spleen	0.68	1.0	0.68			
		Liver	0.73	1.0	0.73			
		Bone	2.8	1.0	2.8			
		Thyroid	0.60	0.99	0.59			
I^{129}	6.3×10^9	Total body	0.089	2.2×10^{-8}	2.0×10^{-9}	0.082	0.089	0.073
		Lung (insol.)	0.082	1.9×10^{-8}	1.6×10^{-9}			
		Kidney	0.077	2.7×10^{-9}	2.1×10^{-10}			
		Testis	0.068	2.2×10^{-8}	1.5×10^{-9}			
		Spleen	0.077	2.2×10^{-9}	1.7×10^{-10}			
		Liver	0.082	5.5×10^{-9}	4.5×10^{-10}			
		Bone	0.30	3.2×10^{-9}	9.6×10^{-10}			
		Thyroid	0.068	2.2×10^{-8}	1.5×10^{-9}			
		Total body			1.1			
		Lung (insol.)			0.83			
		Kidney			0.78			
		Testis	Totals for Chain		0.69			
		Spleen			0.78			
		Liver			0.83			
		Bone			3.2			
		Thyroid			0.68			
$_{52}Te^{129}$	0.051	Total body	0.98	1.0	0.98	0.73	0.98	0.64
		Lung (insol.)	0.73	1.0	0.73			
		Kidney	0.68	1.0	0.68			
		Testis	0.60	1.0	0.60			
		Spleen	0.68	1.0	0.68			
		Liver	0.73	1.0	0.73			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
I^{129}	6.3×10^9	Bone	2.8	1.0	2.8	0.082	0.089	0.073
		Thyroid	0.60	1.0	0.60			
		Total body	0.089	2.2×10^{-8}	2.0×10^{-9}			
		Lung (insol.)	0.082	1.9×10^{-8}	1.6×10^{-9}			
		Kidney	0.077	2.7×10^{-9}	2.1×10^{-10}			
		Testis	0.068	2.2×10^{-8}	1.5×10^{-9}			
		Spleen	0.077	2.2×10^{-9}	1.7×10^{-10}			
		Liver	0.082	5.6×10^{-9}	4.6×10^{-10}			
		Bone	0.030	3.2×10^{-9}	9.6×10^{-11}			
		Thyroid	0.068	2.2×10^{-8}	1.5×10^{-9}			
		Total body	Totals for Chain		0.98			
		Lung (insol.)			0.73			
		Kidney			0.68			
		Testis			0.60			
		Spleen			0.68			
		Liver			0.73			
		Bone			2.8			
		Thyroid			0.60			
$_{52}Te^{131m}$ Te^{131}	1.25	Total body	1.2	1.0	1.2	0.73	1.2	0.55
		Lung (insol.)	0.73	1.0	0.73			
		Kidney	0.63	1.0	0.63			
		Spleen	0.63	1.0	0.63			
		Liver	0.73	1.0	0.73			
		Bone	1.9	1.0	1.9			
		Thyroid	0.47	1.0	0.47			
I^{131} Xe^{131m}	8.05	Total body	0.44	0.94	0.41	0.30	0.44	0.25
		Lung (insol.)	0.30	0.94	0.28			
		Kidney	0.27	0.68	0.18			
		Spleen	0.27	0.63	0.17			
		Liver	0.30	0.81	0.24			
		Bone	1.0	0.71	0.71			
		Thyroid	0.23	0.94	0.22			
		Total body	Totals for Chain		1.6			
		Lung (insol.)			1.0			
		Kidney			0.81			
		Spleen			0.80			
		Liver			0.97			
		Bone			2.6			
		Thyroid			0.69			
$_{52}Te^{132}$	3.2	Total body	0.21	1.0	0.21	0.13	0.21	0.10
		Lung (insol.)	0.13	1.0	0.13			
		Kidney	0.11	1.0	0.11			
		Spleen	0.11	1.0	0.11			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
I^{133}	0.097	Testis	0.089	1.0	0.089	1.0	1.7	0.76
		Bone	0.38	1.0	0.38			
		Liver	0.13	1.0	0.13			
		Thyroid	0.089	1.0	0.089			
		Total body	1.7	1.0	1.7			
		Lung (insol.)	1.0	1.0	1.0			
		Kidney	0.86	0.99	0.85			
		Spleen	0.86	0.99	0.85			
		Testis	0.65	0.99	0.64			
		Bone	2.7	0.99	2.7			
		Liver	1.0	0.99	0.99			
		Thyroid	0.65	1.0	0.65			
		Total body	Totals for Chain		1.9			
		Lung (insol.)			1.1			
		Kidney			0.96			
		Spleen			0.96			
		Testis			0.73			
		Bone			3.1			
		Liver			1.1			
		Thyroid			0.74			
$_{53}I^{133}$	0.87	Total body	0.84	1.0	0.84	0.64	0.84	0.57
Xe^{133m}		Lung (insol.)	0.64	1.0	0.64			
		Thyroid	0.54	1.0	0.54			
Xe^{133}	5.27	Total body	0.17	0.016	0.0027	0.16	0.17	0.15
		Lung (insol.)	0.16	0.016	0.0026			
		Thyroid	0.14	0.016	0.0022			
		Total body	Totals for Chain		0.84			
		Lung (insol.)			0.64			
		Thyroid			0.54			
$_{53}I^{135}$	0.28	Total body	1.2	1.0	1.2	0.70	1.2	0.54
Xe^{135m}		Lung (insol.)	0.70	1.0	0.70			
		Thyroid	0.46	1.0	0.46			
Xe^{135}	0.38	Total body	0.50	0.18	0.090	0.40	0.50	0.36
Cs^{135m}		Lung (insol.)	0.40	0.18	0.072			
		Thyroid	0.33	0.18	0.059			
Cs^{135}	1.1×10^9	Total body	0.066	1.1×10^{-8}	7.3×10^{-10}	0.066	0.066	0.066
		Lung (insol.)	0.066	1.9×10^{-8}	1.3×10^{-9}			
		Thyroid	0.066	1.1×10^{-8}	7.3×10^{-10}			
		Total body	Totals for Chain		1.3			
		Lung (insol.)			0.77			
		Thyroid			0.52			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
$_{55}Cs^{134m}$	0.13	Total body	0.11	1.0	0.11	0.092	0.11	0.083
		Lung (insol.)	0.092	1.0	0.092			
		Liver	0.092	1.0	0.092			
		Spleen	0.087	1.0	0.087			
		Kidney	0.087	1.0	0.087			
		Muscle	0.11	1.0	0.11			
		Bone	0.35	1.0	0.35			
		Lung (sol.)	0.092	1.0	0.092			
Cs^{134}	840	Total body	1.1	0.077	0.085	0.57	1.1	0.38
		Lung (insol.)	0.57	0.13	0.074			
		Liver	0.57	0.096	0.055			
		Spleen	0.46	0.10	0.046			
		Kidney	0.46	0.048	0.022			
		Muscle	1.1	0.14	0.15			
		Bone	0.99	0.14	0.14			
		Lung (sol.)	0.57	0.14	0.080			
		Total body	Totals for Chain		0.19			
		Lung (insol.)			0.17			
		Liver			0.15			
		Spleen			0.13			
		Kidney			0.11			
		Muscle			0.26			
		Bone			0.49			
		Lung (sol.)			0.17			
$_{56}Ba^{131}$	11.6	Total body	0.35	1.0	0.35	0.17	0.35	0.093
		Lung (insol.)	0.17	1.0	0.17			
		Bone	0.093	1.0	0.093			
		Liver	0.17	1.0	0.17			
		Muscle	0.35	1.0	0.35			
		Spleen	0.12	1.0	0.12			
		Kidney	0.12	1.0	0.12			
		Lung (sol.)	0.17	1.0	0.17			
Cs^{131}	10	Total body	0.029	0.88	0.026	0.024	0.029	0.017
		Lung (insol.)	0.024	0.92	0.022			
		Bone	0.017	0.93	0.016			
		Liver	0.024	0.90	0.022			
		Muscle	0.029	0.93	0.027			
		Spleen	0.021	0.91	0.019			
		Kidney	0.021	0.81	0.017			
		Lung (sol.)	0.024	0.93	0.022			
		Total body	Totals for Chain		0.38			
		Lung (insol.)			0.19			
		Bone			0.11			
		Liver			0.19			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Muscle	Totals for Chain		0.38			
		Spleen			0.14			
		Kidney			0.14			
		Lung (sol.)			0.19			
$_{56}Ba^{140}$	12.8	Total body	0.40	1.0	0.40	0.34	0.40	0.32
		Lung (insol.)	0.34	1.0	0.34			
		Bone	1.5	1.0	1.5			
		Liver	0.34	1.0	0.34			
		Lung (sol.)	0.34	1.0	0.34			
		Muscle	0.40	1.0	0.40			
		Spleen	0.33	1.0	0.33			
		Kidney	0.33	1.0	0.33			
La^{140}	1.68	Total body	1.9	1.0	1.9	1.1	1.9	0.80
		Lung (insol.)	1.1	1.0	1.1			
		Bone	2.7	1.0	2.7			
		Liver	1.1	1.0	1.1			
		Lung (sol.)	1.1	1.0	1.1			
		Muscle	1.9	1.0	1.9			
		Spleen	0.92	1.0	0.92			
		Kidney	0.92	1.0	0.92			
		Total body	Totals for Chain		2.3			
		Lung (insol.)			1.4			
		Bone			4.2			
		Liver			1.4			
		Lung (sol.)			1.4			
		Muscle			2.3			
		Spleen			1.2			
		Kidney			1.2			
$_{58}Ce^{143}$	1.33	Total body	0.66	1.0	0.66	0.54	0.66	0.49
		Lung (insol.)	0.54	1.0	0.54			
		Liver	0.54	1.0	0.54			
		Bone	2.2	1.0	2.2			
		Kidney	0.51	1.0	0.51			
Pr^{143}	13.7	Total body	0.32	0.98	0.31	0.32	0.32	0.32
		Lung (insol.)	0.32	0.90	0.29			
		Liver	0.32	0.96	0.31			
		Bone	1.6	0.99	1.6			
		Kidney	0.32	0.98	0.31			
		Total body	Totals for Chain		0.97			
		Lung (insol.)			0.83			
		Liver			0.85			
		Bone			3.8			
		Kidney			0.82			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
$_{58}Ce^{144}$	290	Total body	1.3	1.0	1.3	1.3	1.3	1.3
Pr^{144}		Lung (insol.)	1.3	1.0	1.3			
		Liver	1.3	1.0	1.3			
		Bone	6.3	1.0	6.3			
		Kidney	1.3	1.0	1.3			
Nd^{144}	7.3×10^{17}	Total body	20	9.0×10^{-16}	1.8×10^{-14}	20	20	20
		Lung (insol.)	20	1.6×10^{-16}	3.2×10^{-15}			
		Liver	20	1.8×10^{-16}	3.6×10^{-15}			
		Bone	100	2.0×10^{-15}	2.0×10^{-13}			
		Kidney	20	9.0×10^{-16}	1.8×10^{-14}			
		Total body	Totals for Chain		1.3			
		Lung (insol.)			1.3			
		Bone			6.3			
		Liver			1.3			
		Kidney			1.3			
$_{60}Nd^{147}$	11.3	Total body	0.37	1.0	0.37	0.29	0.37	0.26
		Lung (insol.)	0.29	1.0	0.29			
		Liver	0.29	1.0	0.29			
		Kidney	0.28	1.0	0.28			
		Bone	1.2	1.0	1.2			
Pm^{147}	920	Total body	0.069	0.42	0.029	0.069	0.069	0.069
		Lung (insol.)	0.069	0.12	0.0083			
		Liver	0.069	0.42	0.029			
		Kidney	0.069	0.42	0.029			
		Bone	0.35	0.62	0.22			
Sm^{147}	4.8×10^{13}	Total body	23	5.7×10^{-12}	1.3×10^{-10}	0.22	0.22	0.22
		Lung (insol.)	23	2.9×10^{-13}	6.7×10^{-12}			
		Liver	23	1.6×10^{-12}	3.7×10^{-11}			
		Kidney	23	5.7×10^{-12}	1.3×10^{-10}			
		Bone	115	1.9×10^{-11}	2.1×10^{-9}			
		Total body	Totals for Chain		0.40			
		Lung (insol.)			0.30			
		Liver			0.32			
		Kidney			0.31			
		Bone			1.4			
$_{60}Nd^{149}$	0.083	Total body	0.55	1.0	0.55	0.55	0.55	0.55
		Lung (insol.)	0.55	1.0	0.55			
		Liver	0.55	1.0	0.55			
		Kidney	0.55	1.0	0.55			
		Bone	2.8	1.0	2.8			
Pm^{149}	2.2	Total body	0.54	1.0	0.54	0.44	0.54	0.41
		Lung (insol.)	0.44	1.0	0.44			
		Liver	0.44	1.0	0.44			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Kidney	0.42	1.0	0.42			
		Bone	1.9	1.0	1.9			
		Total body	Totals for Chain		1.1			
		Lung (insol.)			0.99			
		Liver			0.99			
		Kidney			0.97			
		Bone			4.7			
$_{61}Pm^{147}$	920	Total body	0.069	1.0	0.069	0.069	0.069	0.069
		Lung (insol.)	0.069	1.0	0.069			
		Bone	0.35	1.0	0.35			
		Kidney	0.069	1.0	0.069			
		Liver	0.069	1.0	0.069			
Sm^{147}	4.8×10^{13}	Total body	23	1.4×10^{-11}	3.2×10^{-10}	0.22	0.22	0.22
		Lung (insol.)	23	2.5×10^{-12}	5.8×10^{-11}			
		Bone	115	3.1×10^{-11}	3.6×10^{-9}			
		Kidney	23	1.4×10^{-11}	3.2×10^{-10}			
		Liver	23	3.9×10^{-12}	9.0×10^{-11}			
		Total body	Totals for Chain		0.069			
		Lung (insol.)			0.069			
		Bone			0.35			
		Kidney			0.069			
		Liver			0.069			
$_{66}Dy^{166}$	3.4	Total body	0.094	1.0	0.094	0.094	0.094	0.094
		Lung (insol.)	0.094	1.0	0.094			
		Bone	0.47	1.0	0.47			
		Liver	0.094	1.0	0.094			
Ho^{166} Er^{166m}	1.1	Total body	0.70	1.0	0.70	0.69	0.70	0.69
		Lung (insol.)	0.69	0.96	0.66			
		Bone	3.4	1.0	3.4			
		Liver	0.69	1.0	0.69			
		Total body	Totals for Chain		0.79			
		Lung (insol.)			0.75			
		Bone			3.9			
		Liver			0.78			
$_{68}Er^{171}$ Tm^{171m}	0.31	Total body	0.64	1.0	0.64	0.49	0.64	0.43
		Lung (insol.)	0.49	1.0	0.49			
		Bone	1.9	1.0	1.9			
		Kidney	0.45	1.0	0.45			
Tm^{171}	694	Total body	0.030	0.49	0.015	0.030	0.030	0.030
		Lung (insol.)	0.030	0.15	0.0045			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Bone	0.15	0.59	0.089			
		Kidney	0.030	0.33	0.0099			
		Total body	Totals for Chain		0.65			
		Lung (insol.)			0.49			
		Bone			2.0			
		Kidney			0.46			
$_{74}W^{187}$	1.0	Total body	0.68	1.0	0.68	0.44	0.68	0.36
Re^{187m}		Lung (insol.)	0.44	1.0	0.44			
		Liver	0.44	1.0	0.44			
		Bone	1.4	1.0	1.4			
Re^{187}	1.8×10^{13}	Total body	0.012	3.9×10^{-13}	4.7×10^{-15}	0.012	0.012	0.012
		Lung (insol.)	0.012	6.7×10^{-12}	8.0×10^{-14}			
		Liver	0.012	7.8×10^{-13}	9.4×10^{-15}			
		Bone	0.062	1.9×10^{-13}	1.2×10^{-14}			
		Total body	Totals for Chain		0.68			
		Lung (insol.)			0.44			
		Liver			0.44			
		Bone			1.4			
$_{76}Os^{191m}$	0.58	Total body	0.042	1.0	0.042	0.018	0.042	0.0097
		Lung (insol.)	0.018	1.0	0.018			
		Kidney	0.013	1.0	0.013			
		Liver	0.018	1.0	0.018			
Os^{191}	16	Total body	0.16	0.11	0.018	0.12	0.16	0.10
Ir^{191m}		Lung (insol.)	0.12	0.88	0.11			
		Kidney	0.11	0.24	0.026			
		Liver	0.12	0.26	0.031			
		Total body	Totals for Chain		0.060			
		Lung (insol.)			0.13			
		Kidney			0.039			
		Liver			0.049			
$_{78}Pt^{193m}$	3.5	Total body	0.075	1.0	0.075	0.032	0.075	0.017
		Lung (insol.)	0.032	1.0	0.032			
		Kidney	0.023	1.0	0.023			
		Liver	0.032	1.0	0.032			
		Spleen	0.023	1.0	0.023			
Pt^{193}	1.8×10^{5}	Total body	0.043	1.3×10^{-4}	5.6×10^{-6}	0.019	0.043	0.0099
		Lung (insol.)	0.019	6.7×10^{-4}	1.3×10^{-5}			
		Kidney	0.014	3.3×10^{-4}	4.6×10^{-6}			
		Liver	0.019	1.1×10^{-4}	2.1×10^{-6}			
		Spleen	0.014	3.3×10^{-4}	4.6×10^{-6}			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Total body	Totals for Chain		0.075			
		Lung (insol.)			0.032			
		Kidney			0.023			
		Liver			0.032			
		Spleen			0.023			
$_{78}Pt^{197m}$	0.056	Total body	0.30	1.0	0.30	0.28	0.30	0.27
		Lung (insol.)	0.28	1.0	0.28			
		Kidney	0.27	1.0	0.27			
		Liver	0.28	1.0	0.28			
		Spleen	0.27	1.0	0.27			
Pt^{197}	0.75	Total body	0.26	0.97	0.25	0.24	0.26	0.23
		Lung (insol.)	0.24	1.0	0.24			
		Kidney	0.23	0.99	0.23			
		Liver	0.24	0.96	0.23			
		Spleen	0.23	0.99	0.23			
		Total body	Totals for Chain		0.55			
		Lung (insol.)			0.52			
		Kidney			0.50			
		Liver			0.51			
		Spleen			0.50			
$_{80}Hg^{197m}$ Au^{197m}	1.0	Total body	0.22	1.0	0.22	0.15	0.22	0.13
		Lung (insol.)	0.15	1.0	0.15			
		Kidney	0.14	1.0	0.14			
		Spleen	0.14	1.0	0.14			
		Liver	0.15	1.0	0.15			
Hg^{197}	2.7	Total body	0.097	0.78	0.076	0.052	0.097	0.036
		Lung (insol.)	0.052	0.96	0.050			
		Kidney	0.043	0.85	0.037			
		Spleen	0.043	0.78	0.034			
		Liver	0.052	0.85	0.044			
		Total body	Totals for Chain		0.30			
		Lung (insol.)			0.20			
		Kidney			0.18			
		Spleen			0.17			
		Liver			0.19			
$_{82}Pb^{210}$	7.1×10^3	Total body	0.045	1.0	0.045	0.027	0.045	0.019
		Lung (insol.)	0.027	1.0	0.027			
		Kidney	0.023	1.0	0.023			
		Bone	0.051	1.0	0.051			
		Liver	0.027	1.0	0.027			
Bi^{210}	5.0	Total body	0.40	0.50	0.20	0.40	0.40	0.40
Tl^{206}		Lung (insol.)	0.40	0.96	0.38			

Radionuclide	Half-life (T, in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Kidney	0.40	0.54	0.22			
		Bone	2.0	0.72	1.4			
		Liver	0.40	0.76	0.30			
Po^{210}	138.4	Total body	55	0.090	5.0	0.53	0.53	0.53
		Lung (insol.)	55	0.44	24			
		Kidney	55	0.18	9.9			
		Bone	275	0.10	28			
		Liver	55	0.18	9.9			
		Total body			5.2			
		Lung (insol.)			25			
		Kidney	Totals for Chain		10			
		Bone			29			
		Liver			10			
$_{82}Pb^{212}$	0.44	Total body	0.29	1.0	0.29	0.24	0.29	0.22
		Lung (insol.)	0.24	1.0	0.24			
		Kidney	0.23	1.0	0.23			
		Bone	1.0	1.0	1.0			
		Liver	0.24	1.0	0.24			
Bi^{212}	0.042	Total body	83	0.99	82	1.8	2.2	1.7
Po^{212}		Lung (insol.)	83	1.0	83			
Tl^{208}		Kidney	82	0.99	81			
		Bone	410	1.0	410			
		Liver	83	1.0	83			
		Total body			82			
		Lung (insol.)			83			
		Kidney	Totals for Chain		81			
		Bone			410			
		Liver			83			
$_{83}Bi^{210}$	5	Total body	0.40	1.0	0.40	0.40	0.40	0.40
Tl^{206}		Lung (insol.)	0.40	1.0	0.40			
		Kidney	0.40	1.0	0.40			
		Bone	2.0	1.0	2.0			
		Liver	0.40	1.0	0.40			
		Spleen	0.40	1.0	0.40			
Po^{210}	138.4	Total body	55	0.18	9.9	0.53	0.53	0.53
		Lung (insol.)	55	0.46	25			
		Kidney	55	0.33	18			
		Bone	275	0.14	39			
		Liver	55	0.23	13			
		Spleen	55	0.30	17			
		Total body	Totals for Chain		10			
		Lung (insol.)			26			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Kidney	Totals for Chain		19			
		Bone			40			
		Liver			13			
		Spleen			17			
$_{85}At^{211}$ } 41%	0.30	Total body	61	1.0	61	0.59	0.59	0.59
		Lung (insol.)	61	1.0	61			
		Thyroid	61	1.0	61			
		Ovary	61	1.0	61			
		Spleen	61	1.0	61			
Bi^{207} } 41%	2.9×10^3	Total body	1.0	0.0017	0.0017	0.45	1.0	0.24
Pb^{207m} } 41%		Lung (insol.)	0.45	0.040	0.018			
		Thyroid	0.15	3.4×10^{-4}	5.1×10^{-5}			
		Ovary	0.15	0.0017	2.6×10^{-4}			
		Spleen	0.33	0.0034	0.0011			
		Total body	Totals for Chain		61			
		Lung (insol.)			61			
		Thyroid			61			
		Ovary			61			
		Spleen			61			
$_{88}Ra^{224}$	3.64	Total body	194	1.0	194	1.9	1.9	1.9
Rn^{220}		Lung (insol.)	194	1.0	194			
Po^{216}		Bone	194	1.0	194			
Pb^{212}	0.44	Total body	0.29	1.0	0.29	0.24	0.29	0.22
		Lung (insol.)	0.24	1.0	0.24			
		Bone	0.22	1.0	0.22			
Bi^{212}	0.042	Total body	83	0.99	82	1.8	2.2	1.7
Po^{212}		Lung (insol.)	83	1.0	83			
Tl^{208}		Bone	82	1.0	82			
		Total body	Totals for Chain		280			
		Lung (insol.)			280			
		Bone			280			
$_{88}Ra^{226}$	5.9×10^5	Total body	49	1.0	49	0.48	0.48	0.48
		Bone	49	1.0	49			
Rn^{222}	3.83	Total body	200	0.30	60	3.5	4.4	3.2
Po^{218}		Bone	200	0.30	60			
Pb^{214}								
Bi^{214}								
Po^{214}								
Tl^{210}								

Radionuclide	Half-life (T, in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Pb^{210}	7.1×10^3	Total body	0.045	0.051	0.0023	0.027	0.045	0.019
		Bone	0.019	0.087	0.0016			
Bi^{210}	5.0	Total body	0.40	0.025	0.010	0.40	0.40	0.40
Tl^{206}		Bone	0.40	0.063	0.025			
Po^{210}	138.4	Total body	55	0.0046	0.25	0.53	0.53	0.53
		Bone	55	0.0091	0.50			
		Total body	Totals for Chain		110			
		Bone			110			
$_{88}Ra^{228}$	2.4×10^3	Total body	0.0046	1.0	0.0046	0.0046	0.0046	0.0046
		Lung (insol.)	0.0046	1.0	0.0046			
		Bone	0.0046	1.0	0.0046			
Ac^{228}	0.26	Total body	1.1	1.0	1.1	0.74	1.1	0.62
		Lung (insol.)	0.74	1.0	0.74			
		Bone	0.62	1.0	0.62			
Th^{228}	700	Total body	56	0.99	55	0.54	0.54	0.54
		Lung (insol.)	56	0.68	38			
		Bone	56	0.99	55			
Ra^{224}	3.64	Total body	194	0.62	120	1.9	1.9	1.9
Rn^{220}		Lung (insol.)	194	0.44	85			
Po^{216}		Bone	194	0.50	97			
Pb^{212}	0.44	Total body	0.29	0.62	0.18	0.24	0.29	0.22
		Lung (insol.)	0.24	0.44	0.11			
		Bone	0.22	0.50	0.11			
Bi^{212}	0.042	Total body	83	0.62	51	1.8	2.2	1.7
Po^{212}		Lung (insol.)	83	0.44	36			
Tl^{208}		Bone	82	0.50	41			
		Total body	Totals for Chain		230			
		Lung (insol.)			160			
		Bone			190			
$_{89}Ac^{227}$	8.0×10^3	Total body	0.63	1.0	0.63	0.019	0.019	0.019
Fr^{223}		Lung (insol.)	0.63	1.0	0.63			
At^{219}		Bone	3.1	1.0	3.1			
Bi^{215}		Liver	0.63	1.0	0.63			
		Kidney	0.63	1.0	0.63			
Th^{227}	18.4	Total body	62	1.0	62	0.64	0.69	0.62
		Lung (insol.)	61	0.99	60			
		Bone	307	1.0	307			
		Liver	61	1.0	61			
		Kidney	61	1.0	61			
Ra^{223}	11.7	Total body	275	0.50	137	3.7	3.8	3.7
Rn^{219}		Lung (insol.)	275	0.60	165			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Po^{215} Pb^{211} Bi^{211} Tl^{207} Po^{211}		Bone	1370	0.50	687			
		Liver	275	1.7×10^{-4}	0.047			
		Kidney	275	0.0011	0.29			
		Total body	Totals for Chain		200			
		Lung (insol.)			230			
		Bone			1000			
		Liver			62			
		Kidney			62			
$_{89}Ac^{228}$	0.26	Total body	1.1	1.0	1.1	0.74	1.1	0.62
		Lung (insol.)	0.74	1.0	0.74			
		Bone	2.6	1.0	2.6			
		Kidney	0.67	1.0	0.67			
		Liver	0.74	1.0	0.74			
Th^{228}	700	Total body	56	0.99	55	0.54	0.54	0.54
		Lung (insol.)	56	0.68	38			
		Bone	279	0.99	276			
		Kidney	56	0.97	54			
		Liver	56	0.99	55			
Ra^{224} Rn^{220} Po^{216}	3.64	Total body	194	0.62	120	1.9	1.9	1.9
		Lung (insol.)	194	0.44	85			
		Bone	971	0.50	486			
		Kidney	194	0.0016	0.31			
		Liver	194	2.6×10^{-4}	0.051			
Pb^{212}	0.44	Total body	0.29	0.62	0.18	0.24	0.29	0.22
		Lung (insol.)	0.24	0.44	0.11			
		Bone	1.0	0.50	0.50			
		Kidney	0.23	0.0016	3.7×10^{-4}			
		Liver	0.24	2.6×10^{-4}	6.2×10^{-5}			
Bi^{212} Po^{212} Tl^{208}	0.042	Total body	83	0.62	51	1.8	2.2	1.7
		Lung (insol.)	83	0.44	36			
		Bone	411	0.50	206			
		Kidney	82	0.0016	0.13			
		Liver	83	2.6×10^{-4}	0.022			
		Total body	Totals for Chain		230			
		Lung (insol.)			160			
		Bone			970			
		Kidney			55			
		Liver			56			
$_{90}Th^{227}$	18.4	Total body	62	1.0	62	0.64	0.69	0.62
		Lung (insol.)	61	1.0	61			
		Kidney	61	1.0	61			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Ra^{223} Rn^{219} Po^{215} Pb^{211} Bi^{211} Tl^{207} Po^{211}	11.7	Liver	61	1.0	61	3.7	3.8	3.7
		Bone	307	1.0	307			
		Total body	275	0.50	138			
		Lung (insol.)	275	0.61	168			
		Kidney	275	0.0011	0.30			
		Liver	275	1.7×10^{-4}	0.047			
		Bone	1370	0.50	687			
		Total body	Totals for Chain		200			
		Lung (insol.)			230			
		Kidney			61			
		Liver			61			
		Bone			990			
$_{90}Th^{228}$	700	Total body	56	1.0	56	0.54	0.54	0.54
		Lung (insol.)	56	1.0	56			
		Bone	279	1.0	279			
		Kidney	56	1.0	56			
		Liver	56	1.0	56			
Ra^{224} Rn^{220} Po^{216}	3.64	Total body	194	0.63	122	1.9	1.9	1.9
		Lung (insol.)	194	0.65	126			
		Bone	971	0.50	485			
		Kidney	194	0.0017	0.33			
		Liver	194	2.6×10^{-4}	0.051			
Pb^{212}	0.44	Total body	0.29	0.63	0.18	0.24	0.29	0.22
		Lung (insol.)	0.24	0.65	0.16			
		Bone	1.0	0.50	0.50			
		Kidney	0.23	0.0017	3.9×10^{-4}			
		Liver	0.24	2.6×10^{-4}	6.2×10^{-5}			
Bi^{212} Po^{212} Tl^{208}	0.042	Total body	83	0.63	52	1.8	2.2	1.7
		Lung (insol.)	83	0.65	54			
		Bone	411	0.50	206			
		Kidney	82	0.0017	0.14			
		Liver	83	2.6×10^{-4}	0.021			
		Total body	Totals for Chain		230			
		Lung (insol.)			240			
		Bone			970			
		Kidney			56			
		Liver			56			
$_{90}Th^{231}$	1.07	Total body	0.14	1.0	0.14	0.11	0.14	0.093
		Lung (insol.)	0.11	1.0	0.11			
		Bone	0.33	1.0	0.33			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Pa^{231}	1.3×10^7	Kidney	0.10	1.0	0.10	0.60	0.70	0.56
		Liver	0.11	1.0	0.11			
		Total body	51	8.4×10^{-4}	0.043			
		Lung (insol.)	51	9.2×10^{-6}	4.7×10^{-4}			
		Bone	257	9.0×10^{-4}	0.23			
		Kidney	51	8.6×10^{-4}	0.044			
		Liver	51	8.8×10^{-4}	0.045			
		Total body	Totals for Chain		0.18			
		Lung (insol.)			0.11			
		Bone			0.56			
		Kidney			0.14			
		Liver			0.16			
$_{90}Th^{232}$	5.1×10^{12}	Total body	41	1.0	41	0.40	0.41	0.40
		Lung (insol.)	41	1.0	41			
		Bone	205	1.0	205			
		Kidney	41	1.0	41			
		Liver	41	1.0	41			
Ra^{228}	2.4×10^3	Total body	0.0046	0.094	4.3×10^{-4}	0.0046	0.0046	0.0046
		Lung (insol.)	0.0046	0.032	1.5×10^{-4}			
		Bone	0.023	0.074	0.0017			
		Kidney	0.0046	9.7×10^{-6}	4.5×10^{-8}			
		Liver	0.0046	1.5×10^{-6}	6.9×10^{-9}			
Ac^{228}	0.26	Total body	1.1	0.094	0.10	0.74	1.1	0.62
		Lung (insol.)	0.74	0.032	0.024			
		Bone	2.6	0.074	0.19			
		Kidney	0.67	9.7×10^{-6}	6.5×10^{-6}			
		Liver	0.74	1.5×10^{-6}	1.1×10^{-6}			
Th^{228}	700	Total body	56	0.088	4.9	0.54	0.54	0.54
		Lung (insol.)	56	0.021	1.2			
		Bone	279	0.069	19			
		Kidney	56	9.0×10^{-6}	5.0×10^{-4}			
		Liver	56	1.4×10^{-6}	7.8×10^{-5}			
Ra^{224}	3.64	Total body	194	0.056	11	1.9	1.9	1.9
Rn^{220}		Lung (insol.)	194	0.014	2.7			
Po^{216}		Bone	971	0.035	34			
		Kidney	194	1.5×10^{-10}	2.9×10^{-8}			
		Liver	194	3.8×10^{-10}	7.4×10^{-8}			
Pb^{212}	0.44	Total body	0.29	0.056	0.016	0.24	0.29	0.22
		Lung (insol.)	0.24	0.014	0.0034			
		Bone	1.0	0.035	0.035			
		Kidney	0.23	1.5×10^{-10}	3.5×10^{-11}			
		Liver	0.24	3.8×10^{-10}	9.1×10^{-11}			
Bi^{212}	0.042	Total body	83	0.056	4.6	1.8	2.2	1.7
Po^{212}		Lung (insol.)	83	0.014	1.2			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Tl^{208}		Bone	411	0.034	14			
		Kidney	82	1.5×10^{-10}	1.2×10^{-8}			
		Liver	83	3.8×10^{-10}	3.2×10^{-8}			
		Total body			62			
		Lung (insol.)			46			
		Bone	Totals for Chain		270			
		Kidney			41			
		Liver			41			
$_{91}Pa^{230}$	17.7	Total body	0.048	1.0	0.048	0.020	0.048	0.011
		Lung (insol.)	0.020	1.0	0.020			
		Kidney	0.015	1.0	0.015			
		Bone	0.011	1.0	0.011			
Th^{230} 80%	2.9×10^7	Total body	48	3.9×10^{-4}	0.019	0.47	0.47	0.47
		Lung (insol.)	48	4.8×10^{-5}	0.0023			
		Kidney	48	3.3×10^{-4}	0.016			
		Bone	242	4.0×10^{-4}	0.097			
Ra^{226}	5.9×10^5	Total body	49	5.6×10^{-7}	2.7×10^{-5}	0.48	0.48	0.48
		Lung (insol.)	49	6.6×10^{-9}	3.2×10^{-7}			
		Kidney	49	1.3×10^{-11}	6.4×10^{-10}			
		Bone	246	3.4×10^{-7}	8.4×10^{-5}			
		Total body			0.067			
		Lung (insol.)	Totals for Chain		0.022			
		Kidney			0.031			
		Bone			0.11			
$_{91}Pa^{230}$	17.7	Total body	0.13	1.0	0.13	0.13	0.13	0.13
		Lung (insol.)	0.13	1.0	0.13			
		Bone	0.64	1.0	0.64			
		Kidney	0.13	1.0	0.13			
U^{230}	20.8	Total body	348	0.83	289	3.4	3.4	3.4
Th^{226}		Lung (insol.)	348	0.85	296			
Ra^{222}		Bone	1740	0.93	1618			
Rn^{218}		Kidney	348	0.42	146			
Po^{214} 20%								
Pb^{210}	7.1×10^3	Total body	0.045	0.14	0.0063	0.027	0.045	0.019
		Lung (insol.)	0.027	0.014	3.8×10^{-4}			
		Bone	0.051	0.32	0.016			
		Kidney	0.023	0.029	6.7×10^{-4}			
Bi^{210}	5.0	Total body	0.40	0.071	0.028	0.40	0.40	0.40
Tl^{206}		Lung (insol.)	0.40	0.014	0.0056			
		Bone	2.0	0.23	0.46			
		Kidney	0.40	0.016	0.0064			
Po^{210}	138.4	Total body	55	0.013	0.72	0.53	0.53	0.53

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Lung (insol.)	55	0.0063	0.35			
		Bone	275	0.033	9.1			
		Kidney	55	0.0052	0.29			
		Total body	Totals for Chain		290			
		Lung (insol.)			300			
		Bone			1600			
		Kidney			150			
$_{91}Pa^{231}$	1.3×10^7	Total body	52	1.0	52	0.60	0.70	0.56
		Lung (insol.)	51	1.0	51			
		Kidney	51	1.0	51			
		Liver	51	1.0	51			
		Bone	257	1.0	257			
Ac^{227}	8.0×10^3	Total body	0.63	0.45	0.28	0.019	0.019	0.019
Fr^{223}		Lung (insol.)	0.63	0.015	0.0095			
At^{219}		Kidney	0.63	0.45	0.28			
Bi^{215}		Liver	0.63	0.20	0.13			
		Bone	3.1	0.49	1.5			
Th^{227}	18.4	Total body	62	0.45	28	0.64	0.69	0.62
		Lung (insol.)	61	0.015	0.92			
		Kidney	61	0.45	28			
		Liver	61	0.20	12			
		Bone	307	0.49	150			
Ra^{223}	11.7	Total body	275	0.23	63	3.7	3.8	3.7
Rn^{219}		Lung (insol.)	275	0.0087	2.4			
Po^{215}		Kidney	275	4.8×10^{-4}	0.13			
Pb^{211}		Liver	275	3.3×10^{-5}	0.0091			
Bi^{211}		Bone	1370	0.25	343			
Tl^{207}								
Po^{211}								
		Total body	Totals for Chain		140			
		Lung (insol.)			54			
		Kidney			79			
		Liver			63			
		Bone			750			
$_{92}U^{230}$	20.8	Total body	348	1.0	348	3.4	3.4	3.4
Th^{226}		Lung (insol.)	348	1.0	348			
Ra^{222}		Kidney	348	1.0	348			
Rn^{218}		Bone	1740	1.0	1740			
Po^{214}								
Pb^{210}	7.1×10^3	Total body	0.045	0.17	0.0077	0.027	0.045	0.019
		Lung (insol.)	0.027	0.017	4.6×10^{-4}			
		Kidney	0.023	0.070	0.0016			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of Reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Bi^{210}	5.0	Bone	0.051	0.34	0.017			
Tl^{206}		Total body	0.40	0.085	0.034	0.40	0.40	0.40
		Lung (insol.)	0.40	0.016	0.0064			
		Kidney	0.40	0.038	0.015			
Po^{210}	138.4	Bone	2.0	0.25	0.50			
		Total body	55	0.015	0.83	0.53	0.53	0.53
		Lung (insol.)	55	0.0074	0.41			
		Kidney	55	0.013	0.72			
		Bone	275	0.035	9.6			
		Total body	Totals for Chain		350			
		Lung (insol.)			350			
		Kidney			350			
		Bone			1800			
$_{92}U^{232}$	2.7×10^4	Total body	55	1.0	55	0.54	0.54	0.53
		Lung (insol.)	55	1.0	55			
		Kidney	55	1.0	55			
		Bone	274	1.0	274			
Th^{228}	700	Total body	56	0.99	55	0.54	0.54	0.54
		Lung (insol.)	56	0.68	38			
		Kidney	56	0.97	54			
		Bone	279	0.99	276			
Ra^{224}	3.64	Total body	194	0.62	120	1.9	1.9	1.9
Rn^{220}		Lung (insol.)	194	0.44	85			
Po^{216}		Kidney	194	0.0017	0.33			
		Bone	971	0.50	485			
Pb^{212}	0.44	Total body	0.29	0.62	0.18	0.24	0.29	0.22
		Lung (insol.)	0.24	0.44	0.11			
		Kidney	0.23	0.0017	3.9×10^{-4}			
		Bone	1.0	0.50	0.50			
Bi^{212}	0.042	Total body	83	0.62	51	1.8	2.2	1.7
Po^{212}		Lung (insol.)	83	0.44	36			
Tl^{208}		Kidney	82	0.0017	0.14			
		Bone	411	0.50	206			
		Total body	Totals for Chain		280			
		Lung (insol.)			210			
		Kidney			110			
		Bone			1200			
$_{92}U^{235}$	2.6×10^{11}	Total body	46	1.0	46	0.59	0.77	0.52
		Lung (insol.)	46	1.0	46			
		Kidney	46	1.0	46			
		Bone	228	1.0	228			
Th^{231}	1.07	Total body	0.14	1.0	0.14	0.11	0.14	0.093
		Lung (insol.)	0.11	0.99	0.11			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Kidney	0.10	1.0	0.10			
		Bone	0.33	1.0	0.33			
		Total body	Totals for Chain		46			
		Lung (insol.)			46			
		Kidney			46			
		Bone			230			
$_{93}Np^{237}$	8.0×10^8	Total body	49	1.0	49	0.50	0.52	0.49
		Lung (insol.)	49	1.0	49			
		Bone	247	1.0	247			
		Liver	49	1.0	49			
		Kidney	49	1.0	49			
Pa^{233}	27.4	Total body	0.32	1.0	0.32	0.18	0.32	0.13
		Lung (insol.)	0.18	0.81	0.15			
		Bone	0.41	1.0	0.41			
		Liver	0.18	1.0	0.18			
		Kidney	0.15	1.0	0.15			
		Total body	Totals for Chain		49			
		Lung (insol.)			49			
		Bone			250			
		Liver			49			
		Kidney			49			
$_{93}Np^{239}$ Pu^{239m}	2.33	Total body	0.22	1.0	0.22	0.16	0.22	0.14
		Lung (insol.)	0.16	1.0	0.16			
		Bone	0.63	1.0	0.63			
		Kidney	0.15	1.0	0.15			
		Liver	0.16	1.0	0.16			
Pu^{239}	8.9×10^6	Total body	53	0.0013	0.069	0.52	0.52	0.52
		Lung (insol.)	53	4.1×10^{-5}	0.0022			
		Bone	266	0.0013	0.35			
		Kidney	53	0.0012	0.064			
		Liver	53	0.0012	0.064			
		Total body	Totals for Chain		0.29			
		Lung (insol.)			0.16			
		Bone			0.98			
		Kidney			0.21			
		Liver			0.22			
$_{94}Pu^{241}$	4.8×10^3	Total body	0.014	1.0	0.014	0.011	0.012	0.010
		Lung (insol.)	0.013	1.0	0.013			
		Bone	0.048	1.0	0.048			
		Kidney	0.012	1.0	0.012			
		Liver	0.013	1.0	0.013			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Am^{241}	1.7×10^5	Total body	57	0.041	2.3	0.56	0.59	0.56
Np^{237m}		Lung (insol.)	57	7.1×10^{-4}	0.040			
		Bone	283	0.048	14			
		Kidney	57	0.043	2.5			
		Liver	57	0.018	1.0			
		Total body			2.3			
		Lung (insol.)			0.053			
		Bone	Totals for Chain		14			
		Kidney			2.5			
		Liver			1.0			
$_{95}Am^{243}$	2.9×10^6	Total body	54	1.0	54	0.54	0.56	0.54
		Lung (insol.)	54	1.0	54			
		Bone	272	1.0	272			
		Kidney	54	1.0	54			
		Liver	54	1.0	54			
Np^{239}	2.33	Total body	0.22	1.0	0.22	0.16	0.22	0.14
Pu^{239m}		Lung (insol.)	0.16	0.98	0.16			
		Bone	0.63	1.0	0.63			
		Kidney	0.15	1.0	0.15			
		Liver	0.16	0.99	0.16			
Pu^{239}	8.9×10^6	Total body	53	7.3×10^{-4}	0.039	0.52	0.52	0.52
		Lung (insol.)	53	4.0×10^{-5}	0.0021			
		Bone	266	7.4×10^{-4}	0.20			
		Kidney	53	6.7×10^{-4}	0.036			
		Liver	53	9.1×10^{-4}	0.048			
		Total body			54			
		Lung (insol.)			54			
		Bone	Totals for Chain		270			
		Kidney			54			
		Liver			54			
$_{96}Cm^{242}$	162.5	Total body	63	1.0	63	0.62	0.62	0.61
		Lung (insol.)	63	1.0	63			
		Liver	63	1.0	63			
		Bone	315	1.0	315			
		Kidney	63	1.0	63			
Pu^{238}	3.3×10^4	Total body	57	0.29	17	0.55	0.55	0.55
		Lung (insol.)	57	0.011	0.63			
		Liver	57	0.26	15			
		Bone	284	0.29	82			
		Kidney	57	0.27	15			
		Total body	Totals for Chain		80			
		Lung (insol.)			64			

Radionuclide	Half-life (T, in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
		Liver			78			
		Bone	Totals for Chain		400			
		Kidney			78			
$_{96}Cm^{243}$	1.3×10^4	Total body	60	1.0	60	0.64	0.71	0.61
Pu^{239m}		Lung (insol.)	60	1.0	60			
		Bone	299	1.0	299			
		Liver	60	1.0	60			
		Kidney	60	1.0	60			
Pu^{239}	8.9×10^6	Total body	53	8.2×10^{-4}	0.043	0.52	0.52	0.52
		Lung (insol.)	53	4.1×10^{-5}	0.0022			
		Bone	266	7.9×10^{-4}	0.21			
		Liver	53	9.7×10^{-4}	0.051			
		Kidney	53	7.7×10^{-4}	0.041			
		Total body			60			
		Lung (insol.)			60			
		Bone	Totals for Chain		300			
		Liver			60			
		Kidney			60			
$_{96}Cm^{244}$	6.7×10^3	Total body	60	1.0	60	0.58	0.59	0.58
		Lung (insol.)	60	1.0	60			
		Bone	299	1.0	299			
		Liver	60	1.0	60			
		Kidney	60	1.0	60			
Pu^{240}	2.4×10^6	Total body	53	0.0033	0.17	0.52	0.52	0.52
		Lung (insol.)	53	1.5×10^{-4}	0.0080			
		Bone	266	0.0033	0.88			
		Liver	53	0.0037	0.20			
		Kidney	53	0.0031	0.16			
		Total body			60			
		Lung (insol.)			60			
		Bone	Totals for Chain		300			
		Liver			60			
		Kidney			60			
$_{96}Cm^{245}$	7.3×10^6	Total body	55	1.0	55	0.56	0.59	0.55
		Lung (insol.)	55	1.0	55			
		Bone	277	1.0	277			
		Kidney	55	1.0	55			
		Liver	55	1.0	55			
Pu^{241}	4.8×10^3	Total body	0.014	0.65	0.0091	0.011	0.012	0.010
		Lung (insol.)	0.013	0.071	9.2×10^{-4}			
		Bone	0.048	0.63	0.030			

Radionuclide	Half-life (T_r in days)	Effective energy for organs of reference				Eff. energy, ΣE(RBE), (E in MeV) for portions of GI tract		
		Organs of reference	ΣE(RBE)n (E in MeV)	F	ΣEF(RBE)n (E in MeV)	S	SI	LI
Am^{241}	1.7×10^5	Kidney	0.012	0.63	0.0076	0.56	0.59	0.56
		Liver	0.013	0.76	0.010			
Np^{237m}		Total body	57	0.017	0.97			
		Lung (insol.)	57	1.5×10^{-4}	0.0086			
		Bone	283	0.018	5.1			
		Kidney	57	0.017	0.97			
		Liver	57	0.012	0.68			
		Total body	Totals for Chain		56			
		Lung (insol.)			55			
		Bone			280			
		Kidney			56			
		Liver			56			
$_{97}Bk^{249}$	290	Total body	0.026	1.0	0.026	0.026	0.026	0.026
		Lung (insol.)	0.026	1.0	0.026			
		Bone	0.13	1.0	0.13			
Cf^{249}	1.7×10^5	Total body	60	0.064	3.8	0.66	0.76	0.63
		Lung (insol.)	60	7.1×10^{-4}	0.043			
		Bone	301	0.065	20			
		Total body	Totals for Chain		3.8			
		Lung (insol.)			0.069			
		Bone			20			
$_{98}Cf^{250}$	3.7×10^3	Total body	62	1.0	62	0.60	0.60	0.60
		Lung (insol.)	62	1.0	62			
		Bone	310	1.0	310			
Cm^{246}	2.4×10^6	Total body	56	0.0032	0.18	0.54	0.54	0.54
		Lung (insol.)	56	5.0×10^{-5}	0.0028			
		Bone	278	0.0037	1.0			
		Total body	Totals for Chain		62			
		Lung (insol.)			62			
		Bone			310			

Table 6. Element distribution in total body of the standard man
(Average chemical composition of the adult human body)

Element		Per cent by weight	Approximate amount in 70 kg man (g)
Oxygen	(O)	65.0	45,500
Carbon	(C)	18.0	12,600
Hydrogen	(H)	10.0	7000
Nitrogen	(N)	3.0	2100
Calcium	(Ca)	1.5	1050
Phosphorus	(P)	1.0	700
Sulfur	(S)	0.25	175
Potassium	(K)	0.2	140
Sodium	(Na)	0.15	105
Chlorine	(Cl)	0.15	105
Magnesium	(Mg)	0.05	35
Iron	(Fe)	0.0057	4
Zinc	(Zn)	0.0033	2.3
Rubidium	(Rb)	0.0017	1.2
Strontium	(Sr)	2×10^{-4}	0.14
Copper	(Cu)	1.4×10^{-4}	0.1
Aluminum	(Al)	1.4×10^{-4}	0.1
Lead	(Pb)	1.1×10^{-4}	0.08
Tin	(Sn)	4.3×10^{-5}	0.03
Iodine	(I)	4.3×10^{-5}	0.03
Cadmium	(Cd)	4.3×10^{-5}	0.03
Manganese	(Mn)	3×10^{-5}	0.02
Barium	(Ba)	2.3×10^{-5}	0.016
Arsenic	(As)	$<1.4 \times 10^{-4}$	<0.1
Antimony	(Sb)	$<1.3 \times 10^{-4}$	<0.09
Lanthanum	(La)	$<7 \times 10^{-5}$	<0.05
Niobium	(Nb)	$<7 \times 10^{-5}$	<0.05
Titanium	(Ti)	$<2.1 \times 10^{-5}$	<0.015
Nickel	(Ni)	$<1.4 \times 10^{-5}$	<0.01
Boron	(B)	$<1.4 \times 10^{-5}$	<0.01
Chromium	(Cr)	$<8.6 \times 10^{-6}$	<0.006
Ruthenium	(Ru)	$<8.6 \times 10^{-6}$	<0.006
Thallium	(Tl)	$<8.6 \times 10^{-6}$	<0.006
Zirconium	(Zr)	$<8.6 \times 10^{-6}$	<0.006
Molybdenum	(Mo)	$<7 \times 10^{-6}$	<0.005
Cobalt	(Co)	$<4.3 \times 10^{-6}$	<0.003
Beryllium	(Be)	$<3 \times 10^{-6}$	<0.002
Gold	(Au)	$<1.4 \times 10^{-6}$	<0.001
Silver	(Ag)	$<1.4 \times 10^{-6}$	<0.001
Lithium	(Li)	$<1.3 \times 10^{-6}$	$<9 \times 10^{-4}$
Bismuth	(Bi)	$<4.3 \times 10^{-7}$	$<3 \times 10^{-4}$
Vanadium	(V)	$<1.4 \times 10^{-7}$	$<10^{-4}$
Uranium	(U)	3×10^{-8}	2×10^{-5}
Cesium	(Cs)	$<1.4 \times 10^{-8}$	$<10^{-5}$
Gallium	(Ga)	$<3 \times 10^{-9}$	$<2 \times 10^{-6}$
Radium	(Ra)	1.4×10^{-13}	10^{-10}

*Table 7. Elements in the body organs of standard man** (μg/g of wet tissue)

Tissue	Elements										
	Ag	Al	As	Au	B	Ba	Be	Bi	Br	Ca	Cd
Adrenal (6)	0.016	0.62	<1.4	<0.16	<0.11	0.025	<0.01	<0.05		44	<0.4
Aorta (75)	0.015	0.8	<2.8	<0.2	<0.1	0.15	<0.03	<0.15		970	<0.6
Blood		0.16(s)								50	
Bone (99)	<0.1	<0.44	0.01(N)	<2.5	<3	1.63			0.3(N)	148000(w)	N.D.
Brain (94)	0.045	0.29	<4	<0.13	<0.14	<0.01	<0.04	<0.05		110	<0.9
Breast (7)	<0.002	0.4	<2.5	<0.09	<0.08	0.015	<0.03	<0.03		64	<0.2
Gastrointestinal tract											
Esophagus (39)	<0.004	0.82	<2.1	<0.08	<0.07	0.05	<0.02	<0.03		120	<0.5
Stomach (88)	<0.006	0.52	<1.7	<0.07	<0.14	0.038	<0.02	<0.5		115	<0.43
Duodenum (51)	<0.006	0.75	<1.7	<0.07	<0.06	0.038	<0.02	<0.12		86	<0.56
Jejunum (66)	<0.004	0.57	<2.1	<0.13	<0.12	0.04	<0.02	<0.5		76	<0.6
Ileum (68)	<0.005	2	<0.9	<0.1	<0.04	0.088	<0.01	<0.04		135	<26.0
Cecum (31)	<0.009	1.26	<1.2	<0.09	<0.05	0.12	<0.01	<0.1		155	<0.32
Sigmoid colon (72)	<0.007	1.05	<0.9	<0.05	<0.04	0.09	<0.01	<0.04		115	<0.26
Rectum (33)	<0.004	0.74	<0.9	<0.03	<0.03	0.054	<0.01	<0.07		140	<0.24
Heart (96)	<0.006	0.3	<2.6	<0.09	<0.09	0.01	<0.03	<0.04	1.8(s)	53	<0.6
Kidney (102)	<0.01	0.41	0.03(N)	<0.12	<0.12	0.027	<0.03	<0.02	0.4(N)	115	32
Larynx (31)	<0.015	0.61	<4	<0.13	<0.13	0.215	<0.04	<0.08		1920	<0.9
Liver (102)	0.018	0.71	0.1(N)	<0.12	<0.14	<0.013	<0.03	<0.07	2.4(s)	70	2.44
Lung (102)	<0.008	24	0.09(N)	<0.08	<0.09	0.183	<0.02	<0.04	5(s)	130	0.7
Muscle									4.5(s)		
Diaphragm (42)	<0.004	0.35	<1.8	<0.06	<0.06	<0.03	<0.018	<0.05		74	<0.43
Pectoral (21)	<0.005	0.20	<2.7	<0.09	<0.09	<0.011	<0.03	<0.04		37	<0.6
Psoas (86)	<0.007	0.34	<3.0	<0.10	<0.10	<0.014	<0.03	<0.05		49	<0.7
Omentum (35)	0.002	1.26	<0.26	<0.01	<0.01	<0.026	<0.003	<0.12		40	<0.09
Ovary (9)	<0.005	0.7	0.01(N)	<0.07	<0.09	0.04	<0.03	<0.04	0.33(N)	220	<0.6
Pancreas (95)	<0.007	0.47	<2.4	<0.11	<0.11	0.026	<0.02	<0.06		120	1.2
Prostate (27)	0.021	0.89	<2.9	<0.2	<0.15	0.05	<0.03	<0.04		320	<0.76
Skin (18)	0.013	2.8	<1.2	<0.05	<0.12	0.161	<0.01	<0.03		150	<0.28
Spleen (97)	<0.006	1.1	0.02(N)	<0.1	<0.12	<0.022	<0.03	<0.052	4.2(s)	84	<0.74
Testis (53)	<0.005	0.5	0.04(N)	<0.11	<0.09	0.011	<0.03	<0.08	0.33(N)	100	<0.6
Thymus (2)	0.002	0.23	<1.2	<0.04	<0.04	0.009	<0.01	<0.02		63	<0.28
Thyroid (11)	<0.04	1.2	<3.1	<0.1	<0.1	0.26	<0.03	<0.1		260	<0.8
Tongue (3)	<0.005	0.62	<3.2	<0.11	<0.11	0.04	<0.03	<4.4		175	<0.75
Trachea (35)	<0.02	1.85	<3.4	<0.47	<0.13	0.113	<0.03	<0.19		950	<0.8
Urinary bladder (70)	<0.003	0.61	<1.4	<0.1	<0.11	0.03	<0.01	<0.02		130	<0.38
Uterus (17)	<0.005	0.44	<2.6	<0.09	<0.09	0.05	<0.03	<0.04		185	<0.61
Vagina (7)	<0.005	0.3	<2.6	<0.09	<0.09	0.03	<0.03	<0.04		200	<0.58

* Unless otherwise indicated all of these values are taken from the studies of TIPTON *et al.* (Ti–1 through Ti–7) see bibliography. The number in parentheses after the name of the tissue indicates the number of samples of that tissue analyzed. Reports consulted were by TIETZ *et al.*, STITCH, SOWDEN and STITCH, KOCH, SHELDON *et al.* and KEHOE *et al.* (See further references on next two pages.)

(N) Determined by neutron activation (Led- 1 see bibliography).
(F) Determined by flame photometry (Gro- 1, see bibliography).

Table 7—cont.

Tissue	Elements										
	Cl	Co	Cr	Cs	Cu	F	Fe	Ga	I	K	La
Adrenal (6)		<0.04	0.07	<0.7	1.1		43	<0.005		1100	<0.4
Aorta (75)		<0.07	0.06	<1.4	1.3		46	<0.009		1370	<0.9
Blood	320(R)				1(S)	0.3(S)	0.5(S)		390(S)	11	
Bone (99)	1700(E)	0.6(N)	<0.49	6(N)	0.6	200(G)	115		0.3(E)	880	
Brain (94)	1300(E)	<0.05	<0.01	<0.03	5.8	0.5(E)	48	<0.01	0.1(E)	3300	<1.3
Breast (7)		<0.02	0.03		0.36		4.4	<0.003		310	<0.3
Gastrointestinal tract	600								0.4(E)		
Esophagus (39)		<0.03	0.05	<0.01	1.3		34	<0.007		1510	<0.7
Stomach (88)		<0.04	0.03	<0.01	1.7		29	<0.006		1520	<0.6
Duodenum (51)		<0.04	0.03		2.3		39	<0.006		1520	<0.6
Jejunum (66)		<0.04	0.03	<0.02	2		33	<0.007		1600	<0.7
Ileum (68)		<0.04	0.04		1.9		28	<0.003		1230	<0.3
Cecum (31)		<0.26	0.047		1.4		23	<0.004		1060	<0.4
Sigmoid colon (72)		<0.1	0.05	<0.01	1.5		21	<0.003		1320	<0.3
Rectum (33)		<0.06	0.04		1.2		28	<0.003		1580	<0.3
Heart (96)	1250(E)	<0.04	0.02	<0.02	3.51	0.5(E)	50	<0.009	0.9(E)	2500	<0.1
Kidney (102)	2100(E)	0.2(N)	0.03	0.34(N)	2.9	0.8(E)	76	<0.01	0.2(E)	2030	<1
Larynx (31)		<0.05	0.07	<0.03	1.1		28	<0.013		1530	<1.3
Liver (102)	1250(E)	0.3(N)	0.02	0.6(N)	8.6		185	<0.011	1.1(E)	3100	<1.1
Lung (102)	2550(E)	0.06(N)	0.2	0.4(N)	1.3	0.6(E)	300	<0.011		2120	<0.8
Muscle	600(E)					0.4(E)			0.9(E)		
Diaphragm (42)		<0.13	0.04	<0.3	1.35		44	<0.006		2600	<0.6
Pectoral (21)		<0.04	0.03		0.71		28	<0.003		2830	<0.9
Psoas (86)		<0.10	0.03		0.9		36	<0.01		3330	<1
Omentum (35)		<0.01	0.04	<0.002	0.34		28	<0.001		400	<0.09
Ovary (9)		0.02(N)	0.14	0.13(N)	1.06		35	<0.009	0.9(E)	1350	<0.9
Pancreas (95)	1600(E)	<0.05	0.04	0.04	1.7		39	<0.008	0.5(E)	2800	<0.8
Prostate (27)		<0.07	0.05	<0.02	1.4		30	<0.01		2200	<1.0
Skin (18)	2600(E)	<0.02	0.33	<0.01	0.90		16	<0.005	1(E)	800	<0.4
Spleen (97)	1550(E)	0.1(N)	0.02	0.6(N)	1.22	0.3(E)	330	<0.01		3500	<1.1
Testis (53)	2330(E)	0.05(N)	0.03	0.3(N)	1		27	<0.009		2100	<0.9
Thymus (2)		<0.02	0.01		0.42		19	<0.004		540	<0.4
Thyroid (11)	1700(E)	<0.08	0.03	<0.02	1.1		66	<0.01	350(E)	1100	<1
Tongue (3)		<0.04	0.06		1.43		33	<0.011		2800	<1.1
Trachea (35)		<0.05	0.07	<0.02	1.2		47	<0.011		2200	<1.1
Urinary bladder (70)		<0.02	0.04	<0.01	0.95		25	<0.005		1730	<0.5
Uterus (17)		<0.07	0.24	<0.02	0.95		27	<0.009		1730	<0.9
Vagina (7)		<0.14	0.07		0.90		32	<0.009		1500	<0.9

(E) M. EVERETT, *Medical Biochemistry* (2nd Ed.). Hoeber, New York (1946).

(B) E. J. KING and T. H. BELT, The physiological and pathological aspects of silica. *Physiol. Rev.*, *18*, 329–365 (1938).

(S) W. S. SPECTOR (Ed.) *Handbook of Biological Data.* Division of Biology and Agriculture; The National Academy of Sciences; The National Research Council; Wright Air Development Center Technical Report 56–273 (October, 1956).

Table 7—cont.

Tissue	Elements										
	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Ra	Rb
Adrenal (6)		50	0.19	0.57		<0.45	0.28	1000	0.13		
Aorta (75)	0.02	230	0.12	<0.09	2400(F)	<0.9	<0.15	1100	2.51		9.9
Blood	0.02(S)	43	0.14(S)		1750(E)			380	0.3(S)		
Bone (99)	0.003	980	<0.1	<1.5	5×10^3		<2	8×10^4(E)	6.6	1.7×10^{-8}(H)	10
Brain (94)	<0.007	140	0.26	<0.1	1700(F)	<1.3	<0.1	3300	<0.4		28
Breast (7)		20	0.03	<0.03		<0.3	<0.07	140	0.04		
Gastrointestinal tract											
Esophagus (39)	0.013	120	0.12	<0.08	1900(F)	<0.7	<0.09	850	0.16		7.2
Stomach (88)	0.009	100	0.31	<0.06	1300(F)	<0.6	<0.06	1160	0.19		8.6
Duodenum (51)	0.009	100	0.47	<0.06		<0.6	<0.08	1230	0.4		8.6
Jejunum (66)	0.009	120	0.61	<0.07	1600(F)	<0.7	<0.06	1460	0.32		23
Ileum (68)		150	0.63	<0.05		<0.3	<0.13	1000	0.28		
Cecum (31)		200	0.93	<0.04		<0.4	0.24	680	0.28		
Sigmoid colon (72)	0.01	175	0.45	<0.03	1600(F)	<0.3	0.15	800	0.18		5.9
Rectum (33)		180	0.43	<0.03		<0.3	0.14	760	0.49		
Heart (96)	0.008	160	0.19	<0.09	1300(F)	<0.9	<0.12	1600	<0.2		15.1
Kidney (102)	0.008	130	0.85	0.40	2200(F)	<1	<0.09	1700	1.24		10.7
Larynx (31)	0.03	300	0.19	<0.13	2700(F)	<1.3	<0.17	1700	2.2		12.6
Liver (102)	<0.006	165	1.3	1.13	1400(F)	<1.1	<0.11	2700	2		63
Lung (102)	<0.03	95	0.18	<0.08	1900(F)	<0.8	<0.27	1110	0.68		7.3
Muscle											
Diaphragm (42)		140	0.13	<0.06	1600(F)	<0.6	<0.08	1200	0.17		
Pectoral (21)		145	0.05	<0.09	1900(F)	<0.9	<0.11	1440	0.19		
Psoas (86)	<0.005	190	0.05	<0.1		<1	<0.11	1700	0.14		31
Omentum (35)	0.005	22	0.05	<0.01	350(F)	<0.09	0.04	170	0.14		2.0
Ovary (9)	0.011	86	0.17	<0.09		<0.9	<0.1	940	0.13		4.5
Pancreas (95)	<0.005	165	1.16	<0.08	1400(F)	<0.8	<0.09	2500	0.72		62
Prostate (27)	0.013	175	0.22	<0.1	2000(F)	<1	<0.1	1100	0.91		6.9
Skin (18)	0.021	73	0.2	<0.05	920(F)	<0.4	0.44	310	0.55		2.0
Spleen (97)	<0.006	130	0.11	<0.11	1200(F)	<1.1	<0.1	2200	0.67		43
Testis (53)	0.009	115	0.14	<0.09	2100(F)	<0.9	<0.09	1400	0.15		12
Thymus (2)		27	0.04	<0.04		<0.4	<0.04	370	0.07		
Thyroid (11)	0.023	73	0.23	<0.1	2200(F)	<1.0	<0.11	520	0.14		4.2
Tongue (3)		175	0.23	<0.11		<1.1	0.24	1300	<0.06		
Trachea (35)	0.044	260	0.18	<0.11	3000(F)	<1.1	0.18	880	1.1		21
Urinary bladder (70)	0.014	130	0.14	<0.05	1600(F)	<0.5	<0.08	740	0.17		6.6
Uterus (17)	0.004	110	0.10	<0.09	2000(F)	<0.9	<0.23	1000	0.19		5.6
Vagina (7)		85	0.09	<0.09		<0.9	<0.13	6100	0.16		

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(W) B. Harrow, *Textbook of Biochemistry* (3rd Ed.). Saunders, Philadelphia (1943).
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Table 7—cont.

Tissue	Elements										
	Ru	Sb	Si	Sn	Sr	Te	Ti	Tl	V	Zn	Zr
Adrenal (6)	<0.05	<0.9	125(B)	0.19	0.02		<0.13	<0.05	<0.005	8.4	<0.5
Aorta (75)	<0.09	<2.8		0.41	0.43		<0.17	<0.09	<0.01	26	<0.9
Blood			2.5(S)	0.23(S)						9.3(S)	
Bone (99)		0.2(N)		<1.3	15	321(N)	<1		<1.5	66	
Brain (94)	<0.13	<4.0	26(B)	<0.1	0.04		<0.15	<0.13	<0.01	13	<1.3
Breast (7)	<0.04	<2.5		0.26	0.06		<0.05	<0.04	<0.004	2.8	<0.4
Gastrointestinal tract			41(B)								
Esophagus(39)	<0.07	<2.1		0.8	0.1		<0.12	<0.07	<0.007	22	<0.7
Stomach (88)	<0.06	<1.7		0.35	0.12		<0.07	<0.06	<0.012	18	<0.6
Duodenum (51)	<0.06	<1.7		0.54	0.12		<0.08	<0.06	<0.007	20	<0.6
Jejunum (66)	<0.07	<2.1		0.52	0.15		<0.08	<0.07	<0.008	20	<0.7
Ileum (68)	<0.03	<0.9		1.13	0.22		<0.06	<0.03	<0.018	21	<0.3
Cecum (31)	<0.04	<1.2		2.2	0.31		<0.06	<0.04	<0.015	22	<0.4
Sigmoid colon (72)	<0.03	<0.9		0.6	0.25		<0.1	<0.03	<0.047	18	<0.3
Rectum (33)	<0.03	<0.9		0.94	0.19		<0.08	<0.03	<0.037	26	<0.3
Heart (96)	<0.09	<2.6	25(B)	<0.15	0.05		<0.09	<0.09	<0.009	27	<0.9
Kidney (102)	<0.1	0.3(N)	21(B)	0.28	0.08	62(N)	<0.14	<0.1	<0.011	48	<1
Larynx (31)	<0.1	<4		0.18	1.0		<0.17	<0.13	<0.013	29	<1.3
Liver (102)	<0.1	0.2(N)	24(B)	0.4	0.03	1075(N)	<0.14	<0.11	<0.014	46	<1
Lung (102)	<0.08	0.1(N)	130(B)	0.74	0.12	13(N)	2.8	<0.08	<0.071	14	<0.8
Muscle			12(B)								
Diaphragm (42)	<0.06	<1.8		<0.09	0.06		<0.07	<0.06	<0.006	43	<0.6
Pectoral (21)	<0.09	<2.7		<0.21	0.02		<0.10	<0.09	<0.009	46	<0.9
Psoas (86)	<0.1	<3.0		<0.11	0.03		<0.10	<0.1	<0.01	51	<1
Omentum (35)	<0.01	<0.26		0.03	0.04		0.07	<0.01	<0.002	3.3	<0.0
Ovary (9)	<0.09	0.03(N)	18(B)	1.15	0.25	14(N)	<0.1	<0.09	<0.009	13	<0.9
Pancreas (95)	<0.08	<2.4	34(B)	<0.27	0.07		<0.11	<0.08	<0.008	27	<0.8
Prostate (27)	<0.1	<2.9	70(B)	0.31	0.24		<0.16	<0.1	<0.01	87	<1
Skin (18)	<0.04	<1.2	55(B)	0.28	0.1		0.61	<0.04	<0.008	6	<0.4
Spleen (97)	<0.11	0.1(N)	34(B)	0.24	0.05	260(N)	<0.18	<0.11	<0.013	19	<1.1
Testis (53)	<0.09	0.05(N)	31(B)	0.21	0.06	42(N)	<0.1	<0.08	<0.009	15	<0.9
Thymus (2)	<0.04	<1.2	260(B)	0.05	0.05		<0.06	<0.04	<0.004	4.2	<0.4
Thyroid (11)	<0.1	<3.1	45(B)	0.28	0.13		<0.49	<0.1	<0.01	27	<1
Tongue (3)	<0.11	<3.2		0.14	0.07		<0.11	<0.11	<0.011	29	<1.1
Trachea (35)	<0.11	<3.4		0.51	0.48		<0.26	<0.11	<0.01	15	<1.1
Urinary bladder (70)	<0.05	<1.4	19(B)	0.25	0.15		<0.09	<0.05	<0.006	22	<0.5
Uterus (17)	<0.09	<2.6		0.1	0.15		<0.1	<0.09	<0.009	20	<0.9
Vagina (7)	<0.09	<2.6		0.2	0.17		<0.1	<0.09	<0.009	16	<0.9

Table 8. Organs of standard man

Mass and effective radius of organs of the adult human body

	Mass, m (g)	Per cent of total body*	Effective radius, X (cm)
Total body*	70,000	100	30
Muscle	30,000	43	30
Skin and subcutaneous tissue†	6100	8.7	0.1
Fat	10,000	14	20
Skeleton			
Without bone marrow	7000	10	5
Red marrow	1500	2.1	
Yellow marrow	1500	2.1	
Blood	5400	7.7	
Gastrointestinal tract*	2000	2.9	30
Contents of GI tract			
Lower large intestine	150		5
Stomach	250		10
Small intestine	1100		30
Upper large intestine	135		5
Liver	1700	2.4	10
Brain	1500	2.1	15
Lungs (2)	1000	1.4	10
Lymphoid tissue	700	1.0	
Kidneys (2)	300	0.43	7
Heart	300	0.43	7
Spleen	150	0.21	7
Urinary bladder	150	0.21	
Pancreas	70	0.10	5
Salivary glands (6)	50	0.071	
Testes (2)	40	0.057	3
Spinal Cord	30	0.043	1
Eyes (2)	30	0.043	0.25
Thyroid gland	20	0.029	3
Teeth	20	0.029	
Prostate gland	20	0.029	3
Adrenal glands or suprarenal (2)	20	0.029	3
Thymus	10	0.014	
Ovaries (2)	8	0.011	3
Hypophysis (Pituitary)	0.6	8.6×10^{-6}	0.5
Pineal Gland	0.2	2.9×10^{-6}	0.04
Parathyroids (4)	0.15	2.1×10^{-6}	0.06
Miscellaneous (blood vessels, cartilage, nerves, etc.)	390	0.56	

* Does not include contents of the gastrointestinal tract.

† The mass of the skin alone is taken to be 2000 grams.

Table 9. Intake and excretion of the standard man

Water balance

Intake	(cm³/day)	Excretion	(cm³/day)
Food	1000	Urine	1400
Fluids	1200	Sweat	600
Oxidation	300	From lungs	300
		Feces	200
Total	2500	Total	2500

Air balance

	O_2 (vol. %)	CO_2 (vol. %)	N_2 + others (vol. %)
Inspired air	20.94	0.03	79.03
Expired air	16	4.0	80
Alveolar air (inspired)	15	5.6	—
Alveolar air (expired)	14	6.0	—

Vital capacity of lungs	3–4 liters (men) 2–3 liters (women)
Air inhaled during 8 hr work day	10^7 cm³/day
Air inhaled during 16 hr not at work	10^7 cm³/day
Total	2×10^7 cm³/day
Interchange area of lungs	50 m²
Area of upper respiratory tract, trachea, bronchi	20 m²
Total surface area of respiratory tract	70 m²

Total water in body = 4.3×10^4 g.
Average life span of man = 70 years.
Occupational exposure time of man = 8 hours/day; 40 hours/week; 50 weeks/year; 50 years total time.

Table 10. Particulates in respiratory tract of the standard man

Retention of particulate matter in the lungs depends on many factors, such as the size, shape and density of the particles, the chemical form and whether or not the person is a mouth breather; however, when specific data are lacking it is assumed the distribution is as shown below.

Distribution	Readily soluble compounds (%)	Other compounds (%)
Exhaled	25	25
Deposited in upper respiratory passages and subsequently swallowed	50	50
Deposited in the lungs (lower respiratory passages)	25 (this is taken up into the body)	25*

* Of this, half is eliminated from the lungs and swallowed in the first 24 hrs, making a total of 62½ per cent swallowed. The remaining 12½ per cent is retained in the lungs with a half-life of 120 days, it being assumed that this portion is taken up into body fluids.

Table 11. Gastrointestinal tract of the standard man

Portion of GI tract that is the critical tissue	Mass of contents (g)	Time food remains, τ (day)	Fraction from lung to GI tract, f_a (sol.)	(insol.)
Stomach (S)	250	1/24	0.50	0.625
Small intestine (SI)	1100	4/24	0.50	0.625
Upper large intestine (ULI)	135	8/24	0.50	0.625
Lower large intestine (LLI)	150	18/24	0.50	0.625

Table 12. Biological and related physical constants

References are to Bibliography for Biological Data, Pergamon Press

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
1	H	300 (Hw-1)	Total body 7×10^4 g 30 cm	0.1 (Ch-1)		12 (Ln-11 Ln-12)		1.0 (G)	1.0 (D)		1.0 (D)	1.0	1.0 (Ln-20)
	H^3				4.5×10^3		12			1.0 (D)			
	H		Body water 4.3×10^4 g (Ln-11)	0.11 (Ch-1)		12 (Ln-11 Ln-12)			1.0 (D)		1.0 (Ln-20 Hy-9)	1.0 (Ln-20 Hy-9)	1.0 (Ln-20 Hy-9)
	H^3				4.5×10^3		12			1.0 (D)			
2	He		Total body 7×10^4 g 30 cm					1.0 (G)	1.0 (D)		1.0 (D)	1.0	0.75
3	Li	2×10^{-3} (Mow-1)	Total body 7×10^4 g 30 cm	$<1.3\times10^{-8}$ (Ti-1 through Ti-7)		2 (eq. 48)		1.0 (compared to Na Ra-1 Rn-1)	1.0 (D)		1.0 (D)	1.0	0.75
			Ovaries 8 g 3 cm	$<1.1\times10^{-8}$ (Ti-1 through Ti-7)		2 (eq. 48)			10^{-4} (Ti-1 through Ti-7)		10^{-4} (Same as f_2)	10^{-4}	7.5×10^{-5}
			Testes 40 g 3 cm	$<9\times10^{-9}$ (Ti-1 through Ti-7)		2 (eq. 48)			4.2×10^{-4} (Ti-1 through Ti-7)		4.2×10^{-4} (same as f_2)	4.2×10^{-4}	3.2×10^{-4}

4	Be		Total body 7×10^4 g 30 cm	$<3\times10^{-8}$ (Ti-1 through Ti-7)		180		2×10^{-3} (Ha-12)	1.0 (D)		1.0 (D)	2×10^{-3}	0.25
	Be^7				53.6		41			1.0 (D)			
	Be		Kidneys 300 g 7 cm	$<3\times10^{-8}$ (Ti-1 through Ti-7)		120			0.02 (Ha-16 Ha-21 Ha-23 Vc-1)		0.03 (Ha-16 Ha-21 Ha-23 Vc-1)	6×10^{-5}	7.5×10^{-3}
	Be^7				53.6		37			0.027			
	Be		Liver 1.7×10^3 g 10 cm	$<3\times10^{-8}$ (Ti-1 through Ti-7)		270			0.15 (Ha-16 Ha-21 Ha-23 Vc-1)		0.1 (Ha-16 Ha-21 Ha-23 Vc-1)	2×10^{-4}	0.025
	Be^7				53.6		45			0.11			
	Be		Spleen 150 g 7 cm	$<3\times10^{-8}$ (Ti-1 through Ti-7)		540			6×10^{-3} (Ha-16 Ha-21 Ha-23 Vc-1)		2×10^{-3} (Ha-16 Ha-21 Ha-23 Vc-1)	4×10^{-6}	5×10^{-4}
	Be^7				53.6		49			2.4×10^{-3}			
	Be		Bone 7×10^3 g 5 cm			450 (Ha-16 Ha-21 Ha-65)			0.8 (Ha-16 Ha-21 Ha-23 Vc-1)		0.32 (Ha-16 Ha-21 Ha-23 Vc-1)	6.4×10^{-4}	0.08
	Be^7				53.6		48			0.37			
5	B	6×10^{-3} (Ti-3 Un-1)	Total body 7×10^4 g 30 cm	$<1.4\times10^{-7}$ (Ti-1 through Ti-7)		0.5 (eq. 48)		0.9 (Un-1)	1.0 (D)		1.0 (D)	0.9	0.7

* Reference equations unless otherwise indicated.

Gen.* ref. Z	Element and radio-nuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concen-tration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Bio-logical T_b	Effective T		Element	Radio-nuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	B		Liver 1.7×10^3 g 10 cm	$<1.4\times10^{-7}$ (Ti-1 through (Ti-7)		0.5			0.13 (Ti-1 through (Ti-7)		0.13 (same as f_2)	0.12	0.09
			Brain 1.5×10^3 g 15 cm	$<1.4\times10^{-7}$ (Ti-1 through Ti-7)		0.5			0.07 (Ti-1 through Ti-7)		0.07 (same as f_2)	0.06	0.05
			Pancreas 70 g 5 cm	$<1.1\times10^{-7}$ (Ti-1 through Ti-7)		0.5			0.03 (Ti-1 through Ti-7)		0.03 (same as f_2)	0.03	0.02
6	C	400 (Hw-1)	Total body 7×10^4 g 30 cm	0.18 (Ch-1)		10 (Na-2)		1.0 (Hw-1)	1.0 (D)		1.0 (D)	1.0	0.75
	C^{14}				2×10^6		10			1.0 (D)			
	C		Fat 10^4 g	0.75 (Ev-1)		12 (Ss-3)			0.6 (Hw-1)		0.5 (eq. 47)	0.5 (Hw-1 G)	0.38
	C^{14}				2×10^6		12			0.6			
	C		Bone 7×10^3 g 5 cm	0.13 (Ev-1)		40 (Se-1) Br-2			0.1 (Hw-1 Ev-1)		0.025 (Sk-2)	0.025	0.02
	C^{14}				2×10^6	Dk-1)	40			0.1			
7	N	16 (Ev-1)	Total body 7×10^4 g 30 cm	0.03 (Ch-1)		90 (eq. 48)		1.0 (Sp-1 Ev-1)	1.0 (D)		1.0 (D)	1.0	0.75

8	O	2300 (Hw-1 Ch-1)	Total body 7×10^4 g 30 cm	0.65 (Ch-1)		14 (eq. 48)		1.0 (G)	1.0 (D)		1.0 (D)	1.0	0.75
9	F	10^{-3} (Un-1 Gd-1)	Total body 7×10^4 g 30 cm	2×10^{-5} (Ev-1 Gd-1)		808		1.0 (compared to Cl, Br and I)	1.0 (D)		1.0 (D)	1.0	0.75
	F^{18}				0.078		0.078			1.0 (D)			
	F		Bone and teeth 7×10^3 g 5 cm	2×10^{-4} (Ev-1)		1450 (eq. 48)			0.95 (Ev-1)		0.53 (Wa-2)	0.53	0.4
	F^{18}				0.078		0.078			0.53			
10	Ne		Total body 7×10^4 g 30 cm					1.0 (G)	1.0 (D)		1.0 (D)	1.0	0.75
11	Na	4 (Ev-1 Sh-1)	Total body 7×10^4 g 30 cm	1.5×10^{-3} (Ch-1)		11 (Rh-1 Ln-18)		1.0 (Gr-14)	1.0 (D)		1.0 (D)	1.0	0.75
	Na^{22}				950		11			1.0 (D)			
	Na^{24}				0.63		0.6			1.0 (D)			
12	Mg	0.53 (Shr-2)	Total body 7×10^4 g 30 cm	5×10^{-4} (Ch-1)		180 (eq. 48)		0.1 (Ev-1)	1.0 (D)		1.0 (D)	0.1	0.3
			Bone 7×10^3 g 5 cm	9.8×10^{-4} (Ti-1 through Ti-7)		180 (eq. 48)			0.5 (Ti-1 through Ti-7)		0.5 (same as f_2)	0.05	0.15
13	Al	2.3×10^{-3} (Ti-3) Ud-1)	Total body 7×10^4 g 30 cm	1.4×10^{-6} (Ti-1 through Ti-7)		550 (eq. 48)		0.1 (Mz-2 G)	1.0 (D)		1.0 (D)	0.1	0.3

* Reference equations unless otherwise indicated

Gen.* ref.	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
Z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	A1		Lungs 10^3 g 10 cm	2.4×10^{-5} (Ti-1 through Ti-7)		600 (eq. 48)			0.14 (Sha-1 Ti-1 through Ti-7)		0.14 (same as f_2)	0.013	0.04
			Spleen 150 g 7 cm	1.1×10^{-6} (Ti-1 through Ti-7)		500 (eq. 48)			2×10^{-3} (Sha-1, Ti-1 through Ti-7)		2×10^{-3} (same as f_2)	2×10^{-4}	6×10^{-4}
14	Si	0.03 (Kg-1 Kg-2 G)	Total body 7×10^4 g 30 cm	3×10^{-5} (Kg-2)		60		0.85 (readily absorbed, G)	1.0 (D)		1.0 (D)	0.85	0.68
	Si^{31}				0.11		0.11			1.0 (D)			
	Si		Lungs 10^3 g 10 cm	1.3×10^{-4} (Kg-2)		60 (eq. 48)			0.1 (Kg-2)		0.1 (same as f_2)	0.09	0.07
	Si^{31}				0.11		0.11			0.1			
	Si		Adrenals 20 g 3 cm	2.6×10^{-5} (Kg-2)		60			10^{-3} (Kg-2)		10^{-3} (same as f_2)	8.5×10^{-4}	7×10^{-4}
	Si^{31}				0.11		0.11			10^{-3}			
	Si		Testes 40 g 3 cm	3×10^{-5} (Kg-2)		60			5×10^{-4} (Kg-2)		5×10^{-4} (same as f_2)	4.3×10^{-4}	3.4×10^{-4}
	Si^{31}				0.11		0.11			5×10^{-4}			

	Si Si^{71}		Ovaries 8 g 3 cm	1.7×10^{-5} (Kg-2)	0.11	60	0.11		6×10^{-5} (Kg-2)	6×10^{-5}	6×10^{-5} (same as f_2)	5×10^{-5}	4×10^{-5}
	Si Si^{31}		Skin 2×10^{3} g 0.1 cm	5.5×10^{-5} (Kg-2)	0.11	60	0.11		0.04 (Kg-2)	0.04	0.04 (same as f_2)	0.03	0.03
15	P P^{32}	1.4 (Shr-2 Ev-1 Sun-3)	Total body 7×10^{4} g 30 cm	0.01 (Ch-1)	14.3	257	13.5	0.75 (Kw-1)	1.0 (D)	1.0 (D)	1.0 (D)	0.75 (Kw-1)	0.63
	P P^{32}		Liver 1.7×10^{3} g 10 cm	2.7×10^{-3} (Ti-1 through Ti-7)	14.3	18	8		5×10^{-3} (Ti-1 through Ti-7)	0.04	0.07	0.05 (Kw-1)	0.04
	P P^{32}		Bone 7×10^{3} g 5 cm	0.05 (Ev-1)	14.3	1155 (eq. 48)	14.1		0.9 (He-1)	0.5	0.2 (Ph-4)	0.375	0.32
	P P^{32}		Brain 1.5×10^{3} g 15 cm	3.2×10^{-3} (Ti-1 through Ti-7)	14.3	257	13.5		7×10^{-3} (Ti-1 through Ti-7)	7×10^{-3}	7×10^{-3} (same as f_2)	5.3×10^{-3}	4.4×10^{-3}
16	S S^{35}	1.3 (Hw-1 Sun-1)	Total body 7×10^{4} g 30 cm	2.5×10^{-3} (Ch-1)	87.1	90 (eq. 48)	44.3	1.0 (Dd-6)	1.0 (D)	1.0 (D)	1.0 (D)	1.0	0.75
	S		Bone 7×10^{3} g 5 cm	2.4×10^{-3} (Sh-1)		600			0.2 (Dd-6 Sh-1)		0.03 (eq. 47)	0.03 (Dd-6)	0.02

* Reference equations unless otherwise indicated.

Gen.* ref. Z	Element and radio-nuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concen-tration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Bio-logical T_b	Effective T		Element	Radio-nuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	S^{35}				87.1		76.1			0.05			
	S		Skin 2×10^3g 0.1 cm	9.5×10^{-3} (Sh-1)		1530			0.17 (Sh-1)		0.01 (eq. 47)	0.01 (Dd-6)	7.5×10^{-3}
	S^{35}				87.1		82.4			0.02			
	S		Testes 40 g 3 cm			623			9×10^{-6} (Dd-6)		1.3×10^{-3}	1.3×10^{-3} (Dd-6)	9.8×10^{-4}
	S^{35}				87.1		76.4			2×10^{-3}			
17	Cl	6.7 (Ev-1)	Total body 7×10^4 g 30 cm	1.5×10^{-3} (Ch-1)		29		1.0	1.0 (D)		1.0 (D)	1.0	0.75
	Cl^{36}				1.2×10^8		29			1.0 (D)			
	Cl^{38}				0.026		0.026			1.0 (D)			
18	A		Total body 7×10^4 g 30 cm					1.0 (G)	1.0 (D)		1.0 (D)	1.0	0.75
	A^{37}				34.1					1.0 (D)			
	A^{41}				0.076					1.0 (D)			
19	K	3 (Jl-1)	Total body 7×10^4 g 30 cm	2×10^{-3} (Ch-1)		58		1.0 (He-1)	1.0 (D)		1.0 (D)	1.0	0.75
	K^{42}				0.52		0.52			1.0 (D)			

	K		Muscle 3×10^4 g 30 cm	2.9×10^{-3} (Ti-1 through Ti-7)		58 (Ln-18)			0.65 (Ti-1 through Ti-7)		0.65 (same as f_2)	0.65	0.49
	K^{42}				0.52		0.52			0.65			
	K		Spleen 150 g 7 cm	3.5×10^{-3} (Ti-1 through Ti-7)		58			4×10^{-3} (Ti-1 through Ti-7)		4×10^{-3} (same as f_2)	4×10^{-3}	3×10^{-3}
	K^{42}				0.52		0.52			4×10^{-3}			
	K		Brain 1.5×10^3 g 15 cm	3.3×10^{-3} (Ti-1 through Ti-7)		58			0.04 (Ti-1 through Ti-7)		0.04 (same as f_2)	0.04	0.03
	K^{42}				0.52		0.52			0.04			
	K		Liver 1.7×10^3 g 10 cm	3.1×10^{-3} (Ti-1 through Ti-7)		58			0.02 (Ti-1 through Ti-7)		0.02 (same as f_2)	0.02	0.015
	K^{42}				0.52		0.52			0.02			
20	Ca	1.0 (Shr-2 Ev-1 Jl-1)	Total body 7×10^4 g 30 cm	0.015 (Ch-1)		1.64×10^4		0.6 (Pit-1)	1.0 (D)		1.0 (D)	0.6	0.55
	Ca^{45}				164		162			1.0 (D)			
	Ca^{47}				4.9		4.9			1.0 (D)			
	Ca		Bone 7×10^3 g 5 cm	0.148 (Ev-1) Hw-1)		1.8×10^4 (No-2 compared to Sr and Ra)			0.99 (Ev-1 Hr-1)		0.9 (Co-9 Br-10)	0.54	0.5
	Ca^{45}				164		162			0.9			
	Ca^{47}				4.9		4.9			0.9			
21	Sc		Total body 7×10^4 g 30 cm			30 (Ha-84 Ha-88)		10^{-4} (Ha-84 Ha-88)	1.0 (D)		1.0 (D)	10^{-4}	0.25

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Sc^{46}				85		22			1.0 (D)			
	Sc^{47}				3.43		3.1			1.0 (D)			
	Sc^{48}				1.83		1.7			1.0 (D)			
	Sc		Liver 1.7×10^3 g 10 cm			36			0.18 (Ha-84 Ha-88)		0.15 (Ha-84 Ha-88)	1.5×10^{-5}	0.04
	Sc^{46}				85		25			0.17			
	Sc^{47}				3.43		3.1			0.15			
	Sc^{48}				1.83		1.7			0.15			
	Sc		Kidneys 300 g 7 cm			75			0.05 (Ha-84 Ha-88)		0.02 (Ha-84 Ha-88)	2×10^{-6}	5×10^{-3}
	Sc^{46}				85		40			0.04			
	Sc^{47}				3.43		3.3			0.02			
	Sc^{48}				1.83		1.8			0.02			
	Sc		Bone 7×10^3 g 5 cm			33			0.22 (Ha-84 Ha-88)		0.2 (Ha-84 Ha-88)	2×10^{-5}	0.05
	Sc^{46}				85		24			0.22			
	Sc^{47}				3.43		3.1			0.2			
	Sc^{48}				1.83		1.7			0.2			
22	Ti	5.4×10^{-4} (Ti-3)	Total body 7×10^4 g 30 cm	2.1×10^{-7} (Ti-1 through Ti-7)		320		10^{-4} (compared to Zr)	1.0 (D)		1.0 (D)	10^{-4}	0.25

			Lungs 10^3 g 10 cm	2.8×10^{-6} (Ti-1 through Ti-7)		320 (eq. 48)			0.2 (Ti-1 through Ti-7)		0.2 (same as f_2)	2×10^{-5}	0.05
			Spleen 150 g 7 cm	$<1.8\times10^{-7}$ (Ti-1 through Ti-7)		320			0.01 (Ti-1 through Ti-7)		0.01 (same as f_2)	10^{-6}	2.5×10^{-3}
			Pancreas 70 g 5 cm	$<1.1\times10^{-7}$ (Ti-1 through Ti-7)		320			5×10^{-4} (Ti-1 through Ti-7)		5×10^{-4} (same as f_2)	5×10^{-8}	1.3×10^{-4}
23	V		Total body 7×10^4 g 30 cm	$<1.3\times10^{-8}$ (Ti-1 through Ti-7)		42 (Ha-16 Ha-95)		0.02 (Ha-95)	1.0 (D)		1.0 (D)	0.02	0.26
	V^{48}				16.1		11.6			1.0 (D)			
	V		Kidneys 300 g 7 cm	$<1.1\times10^{-8}$ (Ti-1 through (Ti-7)		74			0.07 (Ha-16 Ha-95)		0.04 (Ha-16 Ha-95)	8×10^{-4}	0.01
	V^{48}				16.1		13.2			0.05			
	V		Spleen 150 g 7 cm	$<1.3\times10^{-8}$ (Ti-1 through Ti-7)		90			0.02 (Ha-16 Ha-95)		0.01 (Ha-16 Ha-95)	2×10^{-4}	2.6×10^{-3}
	V^{48}				16.1		13.7			0.01			
	V		Liver 1.7×10^3 g 10 cm	$<1.4\times10^{-8}$ (Ti-1 through Ti-7)		70			0.1 (Ha-16 Ha-95)		0.06 (Ha-16 Ha-95)	1.2×10^{-3}	0.02
	V^{48}				16.1		13.1			0.07			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	V		Bone 7×10^3 g 5 cm	$<1.5\times10^{-6}$ (Ti-1 through Ti-7)		135			0.45 (Ha-16 Ha-95)		0.14 (Ha-16 Ha-95)	2.8×10^{-3}	0.04
	V^{48}				16.1		14.4			0.17			
24	Cr	1.5×10^{-4} (Ti-3)	Total body 7×10^4 g 30 cm	$<8.6\times10^{-8}$ (Ti-1 through Ti-7)		616		<0.005 (Co-19)	1.0 (D)		1.0 (D)	<0.005	0.25
	Cr^{51}				27.8		26.6			1.0 (D)			
	Cr		Lungs 10^3 g 10 cm	2×10^{-7} (Ti-1 through Ti-7)		616			0.04 (Sha-1 Ti-1 through Ti-7)		0.04 (same as f_2)	2×10^{-4}	0.01
	Cr^{51}				27.8		26.6			0.05			
	Cr		Prostate 20 g 3 cm	5×10^{-8} (Ti-1 through Ti-7)		616 (eq. 48)			9×10^{-4} (Sha-1 Ti-1 through Ti-7)		9×10^{-4} (same as f_2)	4.5×10^{-6}	2.3×10^{-4}
	Cr^{51}				27.8		26.6			9×10^{-4}			
	Cr		Thyroid 20 g 3 cm	3×10^{-8} (Ti-1 through Ti-7)		616			9×10^{-4} (Sha-1 Ti-1 through Ti-7)		9×10^{-4} (same as f_2)	4.5×10^{-6}	2.3×10^{-4}
	Cr^{51}				27.8		26.6			9×10^{-4}			

	Cr		Kidneys 300 g 7 cm	3×10^{-8} (Ti-1 through Ti-7)		616			2.7×10^{-3} (Sha-1 Ti-1 through Ti-7)		2.7×10^{-3} (same as f_2)	1.3×10^{-5}	6.8×10^{-4}
	Cr^{51}				27.8		26.6			2.7×10^{-3}			
25	Mn	3.1×10^{-3} (Ti-3)	Total body 7×10^{4} g 30 cm	3×10^{-7} (Ch-1)		17 (En-2 Bn-3		0.1 (Un-1)	1.0 (D)		1.0 (D)	0.1	0.3
	Mn^{52}				5.55	Bn-4)	2.8			1.0 (D)			
	Mn^{54}				300		5.6			1.0 (D)			
	Mn^{56}				0.11		0.11			1.0 (D)			
	Mn		Pancreas 70 g 5 cm	1.2×10^{-6} (Ti-1 through Ti-7)		5.7			0.01 (Bn-2 Bn-3 Bn-4		0.03 (Bn-2 Bn-3 Bn-4)	3×10^{-3}	9×10^{-3}
	Mn^{52}				5.55		2.8		Bn-6)	0.02			
	Mn^{54}				300		5.6			0.01			
	Mn^{56}				0.11		0.11			0.03			
	Mn		Liver 1.7×10^{3} g 10 cm	1.3×10^{-6} (Ti-1 through Ti-7)		25 (Bn-2 Bn-3 Bn-4)			0.35 (Bn-2 Bn-3 Bn-4		0.24 (Bn-2 Bn-3) Bn-4)	0.02	0.07
	Mn^{52}				5.55		4.5		Bn-6)	0.26			
	Mn^{54}				300		23			0.35			
	Mn^{56}				0.11		0.11			0.24			
	Mn		Kidneys 300 g 7 cm	8.5×10^{-7} (Ti-1 through Ti-7)		6.8			0.02 (Bn-2 Bn-3 Bn-4		0.05 (Bn-2 Bn-3 Bn-4)	5×10^{-3}	0.02
	Mn^{52}				5.55		3.1		Bn-6)	0.04			
	Mn^{54}				300		6.6			0.02			
	Mn^{56}				0.11		0.11			0.05			
26	Fe	0.027 (Ti-3)	Total body 7×10^{4} g 30 cm	5.7×10^{-5} (Ch-1)		800		0.1 (Bad-1)	1.0 (D)		1.0 (D)	0.1	0.3

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Fe^{55}				1.1×10^3		463			1.0 (D)			
	Fe^{59}				45.1		42.7			1.0 (D)			
	Fe		Spleen 150 g 7 cm	3.3×10^{-4} (Ti-1 through Ti-7)		600 (eq. 48)			0.02 (Ti-1 through Ti-7)		0.02 (Ha-29)	2×10^{-3}	6×10^{-3}
	Fe^{55}				1.1×10^3		388			0.02			
	Fe^{59}				45.1		41.9			0.02			
	Fe		Lungs 10^3 g 10 cm	3×10^{-4} (Ti-1 through Ti-7)		3.2×10^3			0.08 (Ti-1 through Ti-7)		0.02 (Ha-29)	2×10^{-3}	6×10^{-3}
	Fe^{55}				1.1×10^3		819			0.035			
	Fe^{59}				45.1		44.5			0.021			
	Fe		Liver 1.7×10^3 g 10 cm	1.9×10^{-4} (Ti-1 through Ti-7)		554			0.09 (Ti-1 through Ti-7)		0.13 (Ha-29)	0.013	0.04
	Fe^{55}				1.1×10^3		368			0.1			
	Fe^{59}				45.1		41.7			0.13			
	Fe		Bone 7×10^3 g 5 cm	1.2×10^{-4} (Ti-1 through Ti-7)		1680			0.21 (Ti-1 through Ti-7)		0.1 (Ha-29)	0.01	0.03
	Fe^{55}				1.1×10^3		665			0.14			
	Fe^{59}				45.1		43.9			0.1			
27	Co	7×10^{-6}	Total body	$<4.3\times10^{-8}$		9.5		0.3	1.0 (D)		1.0 (D)	0.3	0.4

		(Ti-3)	7×10^4 g 30 cm	(Ti-1 through Ti-7)		(Ma-2)		(Gd-1)					
	Co^{57}				270		9.2			1.0 (D)			
	Co^{58m}				0.38		0.37			1.0 (D)			
	Co^{58}				72		8.4			1.0 (D)			
	Co^{60}				1.9×10^3		9.5			1.0 (D)			
	Co		Liver 1.7×10^3 g 10 cm	3×10^{-7} (Led-1)		9.5 (Ma-2)			0.5 (Ma-2)		0.04 (eq. 47)	7×10^{-3} (Ma-2)	0.02
	Co^{57}				270		9.2			0.02			
	Co^{58m}				0.38		0.37			0.02			
	Co^{58}				72		8.4			0.02			
	Co^{60}				1.9×10^3		9.5			0.02			
	Co		Spleen 150 g 7 cm	10^{-7} (Led-1)		9.5 (Ma-2)			0.07 (Ma-2 Co-1 Co-5)		1.4×10^{-3} (eq. 47)	4.2×10^{-4} (Ma-2)	5.6×10^{-4}
	Co^{57}				270		9.2			1.4×10^{-3}			
	Co^{58m}				0.38		0.37			1.4×10^{-3}			
	Co^{58}				72		8.4			1.4×10^{-3}			
	Co^{60}				1.9×10^3		9.5			1.4×10^{-3}			
	Co		Pancreas 70 g 5 cm	$<5\times10^{-8}$ (Ti-1 through Ti-7)		9.5 (Ma-2)			0.03 (Co-1 Co-5)		2×10^{-3} (Co-22)	6×10^{-4}	8×10^{-4}
	Co^{57}				270		9.2			2×10^{-3}			
	Co^{58m}				0.38		0.37			2×10^{-3}			
	Co^{58}				72		8.4			2×10^{-3}			
	Co^{60}				1.9×10^3		9.5			2×10^{-3}			
28	Ni	4×10^{-4} (Ti-3)	Total Body 7×10^4 g 30 cm	$<1.4\times10^{-7}$ (Ti-1 through Ti-7		667		0.3 (Ps-1)	1.0 (D)		1.0 (D)	0.3	0.4

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Gen.* ref. / z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Ni^{59}				2.9×10^{7}		667			1.0 (D)			
	Ni^{63}				2.9×10^{4}		652			1.0 (D)			
	Ni^{65}				0.11		0.11			1.0 (D)			
	Ni		Bone 7×10^{3} g 5 cm	$<2\times10^{-6}$ (Ti-1 through Ti-7)		800 (eq. 48)			0.6 (Ps-1)		0.5 (eq. 47)	0.15 (Ps-1)	0.2
	Ni^{59}				2.9×10^{7}		800			0.6			
	Ni^{63}				2.9×10^{4}		492			0.6			
	Ni^{65}				0.11		0.11			0.5			
	Ni		Liver 1.7×10^{3} g 10 cm	$<10^{-7}$ (Ti-1 through Ti-7)		500			0.05 (Ps-1)		0.07 (eq. 47)	0.02 (Ps-1)	0.03
	Ni^{59}				2.9×10^{7}		500			0.05			
	Ni^{63}				2.9×10^{4}		492			0.05			
	Ni^{65}				0.11		0.11			0.07			
29	Cu	3×10^{-3} (Ti-3)	Total body 7×10^{4} g 30 cm	1.4×10^{-6} (Ch-1)		80		0.28 (Co-3 Co-6)	1.0 (D)		1.0 (D)	0.28	0.39
	Cu^{64}				0.53		0.53			1.0 (D)			
	Cu		Spleen 150 g	1.2×10^{-6} (Ti-1		2			2×10^{-3} (Ti-1		0.07 (Ash-1)	0.02	0.03

	Cu^{64}		7 cm	through Ti-7)	0.53		0.42		through Ti-7)	0.055			
	Cu		Kidneys 300 g 7 cm	2.9×10^{-6} (Ti-1 through Ti-7)		16			0.01 (Ti-1 through Ti-7)		0.05 (Ash-1)	0.01	0.02
	Cu^{64}				0.53		0.51			0.05			
	Cu		Liver 1.7×10^{3} g 10 cm	8.6×10^{-6} (Ti-1 through Ti-7)		150 (eq. 48)			0.15 (Ti-1 through Ti-7)		0.08 (Ash-1)	0.02	0.03
	Cu^{64}				0.53		0.53			0.08			
	Cu		Heart 300 g 7 cm	3.5×10^{-6} (Ti-1 through Ti-7)		80			0.01 (Ti-1 through Ti-7)		0.01 (Ash-1)	3×10^{-3}	4×10^{-3}
	Cu^{64}				0.53		0.53			0.01			
	Cu		Brain 1.5×10^{3} g 15 cm	5.8×10^{-6} (Ti-1 through Ti-7)		800			0.1 (Ti-1 through Ti-7)		0.01 (Ash-1)	3×10^{-3}	4×10^{-3}
	Cu^{64}				0.53		0.53			0.01			
30	Zn	0.017 (Ev-1 Sh-1)	Total body 7×10^{4} g 30 cm	3.3×10^{-5} (Ch-1 Ti-1 through Ti-7)		933 (eq. 48)		0.1 (Sh-1)	1.0 (D)		1.0 (D)	0.1	0.3
	Zn^{65}				245		194			1.0 (D)			
	Zn^{69m}				0.58		0.58			1.0 (D)			
	Zn^{69}				0.036		0.036			1.0 (D)			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Zn		Prostate 20 g 3 cm	8.7×10^{-5} (Ti-1 through Ti-7)		14 (eq. 48)			9×10^{-4} (Ti-1 through Ti-7)		0.06 (Gu-1 Sn-2)	6×10^{-3}	0.02
	Zn^{65}				245		13			4×10^{-3}			
	Zn^{69m}				0.58		0.56			0.06			
	Zn^{69}				0.036		0.036			0.06			
	Zn		Bone 7×10^{3} g 5 cm	6.6×10^{-5} (Ti-1 through Ti-7)		1300			0.21 (Ti-1 through Ti-7)		0.15 (Sn-2)	0.015	0.045
	Zn^{65}				245		206			0.16			
	Zn^{69m}				0.58		0.58			0.15			
	Zn^{69}				0.036		0.036			0.15			
	Zn		Kidneys 300 g 7 cm	4.8×10^{-5} (Ti-1 through Ti-7)		149			6.4×10^{-3} (Ti-1 through Ti-7)		0.04 (Sn-2)	4×10^{-3}	0.012
	Zn^{65}				245		93			0.02			
	Zn^{69m}				0.58		0.58			0.04			
	Zn^{69}				0.036		0.036			0.04			
	Zn		Muscle 3×10^{4} g 30 cm	4.7×10^{-5} (Ti-1 through Ti-7)		1959			0.63 (Ti-1 through Ti-7)		0.3 (Sn-2)	0.03	0.09
	Zn^{65}				245		218			0.34			
	Zn^{69m}				0.58		0.58			0.3			
	Zn^{69}				0.036		0.036			0.3			
	Zn		Liver 1.7×10^{3} g	4.6×10^{-5} (Ti-1		91			0.034 (Ti-1		0.35 (Sn-2	0.035	0.11

			10 cm	through Ti-7)					through Ti-7)				
	Zn^{65}				245		66			0.12			
	Zn^{69m}				0.58		0.58			0.35			
	Zn^{69}				0.036		0.036			0.35			
	Zn		Pancreas 70 g 5 cm	2.7×10^{-5} (Ti-1 through Ti-7)		25			8×10^{-4} (Ti-1 through Ti-7)		0.03 (Sn-2)	3×10^{-3}	9×10^{-3}
	Zn^{65}				245		23			3.5×10^{-3}			
	Zn^{69m}				0.58		0.57			0.03			
	Zn^{69}				0.036		0.036			0.03			
	Zn		Testes 40 g 3 cm	1.5×10^{-5} (Ti-1 through Ti-7)		270			2.6×10^{-4} (Ti-1 through Ti-7)		9×10^{-4} (Sn-2)	9×10^{-5}	2.7×10^{-4}
	Zn^{65}				245		128			6×10^{-4}			
	Zn^{69m}				0.58		0.58			9×10^{-4}			
	Zn^{69}				0.036		0.036			9×10^{-4}			
	Zn		Ovaries 8 g 3 cm	1.3×10^{-5} (Ti-1 through Ti-7)		107			4.6×10^{-5} (Ti-1 through Ti-7)		4×10^{-4} (Sn-2)	4×10^{-5}	1.2×10^{-4}
	Zn^{65}				245		74			1.5×10^{-4}			
	Zn^{69m}				0.58		0.58			4×10^{-4}			
	Zn^{69}				0.036		0.036			4×10^{-4}			
31	Ga		Total body 7×10^{4} g 30 cm	$<3\times10^{-11}$ (Du-1)		6 (Bm-1)		$<10^{-3}$ (Du-4 Pk-1)	1.0 (D)		1.0 (D)	10^{-3}	0.25
	Ga^{72}				0.59		0.54			1.0 (D)			
	Ga		Liver 1.7×10^{3} g 10 cm	$<10^{-8}$ (Ti- 1 through Ti-7)		4.8			0.2 (Ha-20)		0.25 (Bm-1 Ha-20)	2.5×10^{-4}	0.063

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
Z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Ga^{72}				0.59		0.53			0.25			
	Ga		Bone 7×10^3 g 5 cm	$<1\times10^{-6}$ (Du-1)		12			0.6 (Ha-20)		0.3 (Bm-1 Ha-20)	3×10^{-4}	0.075
	Ga^{72}				0.59		0.56			0.31			
	Ga		Spleen 150 g 7 cm	$<10^{-8}$ (Ti-1 through Ti-7)		6			0.01 (Ha-20)		0.01 (Ha-20)	10^{-5}	2.5×10^{-3}
	Ga^{72}				0.59		0.54			0.01			
	Ga		Kidneys 300 g 7 cm	$<10^{-8}$ (Ti-1 through Ti-7)		9			0.03 (Ha-20)		0.02 (Ha-20)	2×10^{-5}	5×10^{-3}
	Ga^{72}				0.59		0.55			0.02			
32	Ge		Total body 7×10^4 g 30 cm			1		<0.01 (Ha-21)	1.0 (D)		1.0 (D)	0.01	0.26
	Ge^{71}				12		0.92			1.0 (D)			
	Ge		Kidneys 300 g 7 cm			12 (Ha-12)			0.36 (Ha-21)		0.03 (Ha-21)	3×10^{-4}	8×10^{-3}
	Ge^{71}				12		6			0.2			
	Ge		Liver 1.7×10^3 g 10 cm			7.5			0.15 (Ha-21)		0.02 (Ha-21)	2×10^{-4}	5×10^{-3}
	Ge^{71}				12		4.6			0.1			

33	As		Total body 7×10^4 g 30 cm	$<1.4\times10^{-6}$ (Ti-1 through Ti-7)		280 (Ha-17)		0.03 (Mo-1)	1.0 (D)		1.0 (D)	0.03	0.27
	As^{73}				76		60			1.0 (D)			
	As^{74}				17.5		16.5			1.0 (D)			
	As^{76}				1.1		1.1			1.0 (D)			
	As^{77}				1.6		1.6			1.0 (D)			
	As		Kidneys 300 g 7 cm	3×10^{-8} (Led-1)		550			0.02 (Ha-17)		0.01 (Ha-17)	3×10^{-4}	2.7×10^{-3}
	As^{73}				76		67			0.01			
	As^{74}				17.5		17			0.01			
	As^{76}				1.1		1.1			0.01			
	As^{77}				1.6		1.6			0.01			
	As		Liver 1.7×10^3 g 10 cm	10^{-7} (Led-1)		550			0.06 (Ha-17)		0.03 (Ha-17)	9×10^{-4}	8×10^{-3}
	As^{73}				76		67			0.034			
	As^{74}				17.5		17			0.031			
	As^{76}				1.1		1.1			0.03			
	As^{77}				1.6		1.6			0.03			
34	Se		Total body 7×10^4 g 30 cm			11 (Ha-15 Ha-22)		0.9 (Un-1 Gd-1 G)	1.0 (D)		1.0 (D)	0.9	0.7
	Se^{75}				127		10.1			1.0 (D)			
	Se		Kidneys 300 g 7 cm			11 (Ha-15 Ha-22)			0.04 (Ha-15 Ha-22)		0.04 (Ha-15)	0.04	0.03
	Se^{75}				127		10.1			0.04			
	Se		Liver			24			0.15		0.07	0.06	0.05

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Gen.* ref.	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
Z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
			1.7×10^3 g 10 cm						(Ha-15 Ha-22)		(Ha-15)		
	Se^{75}				127		20			0.14			
	Se		Spleen 150 g 7 cm			18 (Ha-15 Ha-22)			8×10^{-3} (Ha-15) Ha-22)		5×10^{-3} (Ha-15)	4.5×10^{-3}	3.5×10^{-3}
	Se^{75}				127		16			8×10^{-3}			
35	Br	0.017 (Ev-1)	Total body 7×10^4 g 30 cm	1.7×10^{-6} (Dx-1)		8 (eq. 48)		1.0 (compared to I)	1.0 (D)		1.0 (D)	1.0	0.75
	Br^{82}				1.5		1.3			1.0 (D)			
36	Kr		Total body 7×10^4 g 30 cm					1.0 (G)	1.0 (D)		1.0 (D)	1.0	0.75
	Kr^{85m}				0.18								
	Kr^{85}				3.9×10^3								
	Kr^{87}				0.054								
37	Rb		Total body 7×10^4 g 30 cm	1.7×10^{-5} (Ti-1 through Ti-7)		45		1.0 (Ha-21 Rh-1)	1.0 (D)		1.0 (D)	1.0	0.75
	Rb^{86}				18.6		13.2			1.0 (D)			
	Rb^{87}				1.8×10^{13}		45			1.0 (D)			
	Rb		Muscle 3×10^4 g	3.1×10^{-5} (Ti-1		80 (Ln-18			0.8 (Ha-21)		0.45 (Ha-21)	0.45	0.34

			30 cm	through Ti-7)		Rh-1)							
	Rb^{86}				18.6		15.1			0.52			
	Rb^{87}				1.8×10^{13}		80			0.8			
	Rb		Liver 1.7×10^{3} g 10 cm	6.3×10^{-5} (Ti-1 through Ti-7)		63			0.07 (Ha-21)		0.05 (Ha-21)	0.05	0.04
	Rb^{86}				18.6		14.4			0.06			
	Rb^{87}				1.8×10^{13}		63			0.07			
	Rb		Spleen 150 g 7 cm	4.3×10^{-5} (Ti-1 through Ti-7)		45			4×10^{-3} (Ha-21)		4×10^{-3} (Ha-21)	4×10^{-3}	3×10^{-3}
	Rb^{86}				18.6		13.2			4×10^{-3}			
	Rb^{87}				1.8×10^{13}		45			4×10^{-3}			
	Rb		Pancreas 70 g 5 cm	6.2×10^{-5} (Ti-1 through Ti-7)		60			4×10^{-3} (Ha-21)		3×10^{-3} (Ha-21)	3×10^{-3}	2.3×10^{-3}
	Rb^{86}				18.6		14.3			3.6×10^{-3}			
	Rb^{87}				1.8×10^{13}		60			4×10^{-3}			
38	Sr	10^{-3} (Ti-3)	Total body 7×10^{4} g 30 cm	2×10^{-6} (Ti-1 through Ti-7)		1.3×10^{4}		0.3 (Pit-1)	1.0 (D)		1.0 (D)	0.3	0.4
	Sr^{85m}				0.049		0.049			1.0 (D)			
	Sr^{85}				65		64.7			1.0 (D)			
	Sr^{89}				50.5		50.3			1.0 (D)			
	Sr^{90}				10^{4}		5700			1.0 (D)			
	Sr^{91}				0.4		0.4			1.0 (D)			
	Sr^{92}				0.11		0.11			1.0 (D)			

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Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Sr		Bone 7×10^3 g 5 cm	1.5×10^{-5} (Ti-1 through Ti-7)		1.8×10^4 (No-2 compared to Ca and Ra)			0.95 (Ti-1 through Ti-7)		0.3 (Dur-3)	0.09	0.12
	Sr^{85m}				0.049		0.049			0.71	0.7 (Tm-3)	0.21	0.28
	Sr^{85}				65		64.8			0.99	0.7 (Tm-3)	0.21	0.28
	S^{89}				50.5		50.4			0.99	0.7 (Tm-3)	0.21	0.28
	Sr^{90}				10^4		6.4×10^3			0.99	0.3 (Dur-3)	0.09	0.12
	Sr^{91}				0.4		0.4			0.76	0.7 (Tm-3)	0.21	0.28
	Sr^{92}				0.11		0.11			0.72	0.7 (Tm-3)	0.21	0.28
39	Y		Total body 7×10^4 g 30 cm			1.4×10^4		$<10^{-4}$ (Ha-50 Su-3)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Y^{90}				2.68		2.68			1.0 (D)			
	Y^{91m}				0.035		0.035			1.0 (D)			
	Y^{91}				58		58			1.0 (D)			
	Y^{92}				0.15		0.15			1.0 (D)			
	Y^{93}				0.42		0.42			1.0 (D)			

	Y		Bone 7×10^3 g 5 cm			1.8×10^4 Compared to Sr			0.97 (Tm-1)		0.75 (Tm-1)	7.5×10^{-5}	0.19
	Y^{90}				2.68	(Tm-1 Jy-2)	2.68			0.75			
	Y^{91m}				0.035		0.035			0.75			
	Y^{91}				58		58			0.75			
	Y^{92}				0.15		0.15			0.75			
	Y^{93}				0.42		0.42			0.75			
40	Zr		Total body 7×10^4 g 30 cm	$<8.6 \times 10^{-8}$ (Ti-1 through Ti-7)		450		$<10^{-4}$ (Ha-51 Ha-62)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Zr^{93}				4×10^8		450			1.0 (D)			
	Zr^{95}				63.3		55.5			1.0 (D)			
	Zr^{97}				0.71		0.71			1.0 (D)			
	Zr		Bone 7×10^3 g 5 cm			1000 (compared to 4 f rare earths)			0.8 (Ha-16 Ha-21)		0.36 (Ha-21)	3.6×10^{-5}	0.09
	Z^{93}				4×10^8		1000			0.8			
	Zr^{95}				63.3		59.5			0.38			
	Zr^{97}				0.71		0.71			0.36			
	Zr		Kidneys 300 g 7 cm	$<10^{-6}$ (Ti-1 through Ti-7)		900			0.04 (Ha-16 Ha-21)		0.02 (Ha-21)	2×10^{-6}	5×10^{-3}
	Zr^{93}				4×10^8		900			0.04			
	Zr^{95}				63.3		59			0.02			
	Zr^{97}				0.71		0.71			0.02			

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Gen.* ref.	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
Z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Zr		Spleen 150 g 7 cm	$<10^{-6}$ (Ti-1 through Ti-7)		900			0.01 (Ha-16 Ha-21)		6×10^{-3} (Ha-21)	6×10^{-7}	1.5×10^{-3}
	Zr^{93}				4×10^{8}		900			0.01			
	Zr^{95}				63.3		59			6.4×10^{-3}			
	Zr^{97}				0.71		0.71			6×10^{-3}			
	Zr		Liver 1.7×10^{3} g 10 cm	$<10^{-6}$ (Ti-1 through Ti-7)		320			0.05 (Ha-16 Ha-21)		0.07 (Ha-21)	7×10^{-6}	0.02
	Zr^{93}				4×10^{8}		320			0.05			
	Zr^{95}				63.3		53			0.07			
	Zr^{97}				0.71		0.71			0.07			
41	Nb		Total body 7×10^{4} g 30 cm	$<7\times10^{-7}$ (Ti-1 through Ti-7)		760		$<10^{-4}$ (Ha-62)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Nb^{93m}				3.7×10^{3}		630			1.0 (D)			
	Nb^{95}				35		33.5			1.0 (D)			
	Nb^{97}				0.051		0.051			1.0 (D)			
	Nb		Bone 7×10^{3} g 5 cm			1000 (Ha-55 Ha-62			0.5 (Ha-26)		0.38 (Ha-26)	3.8×10^{-5}	0.1

	Nb^{93m} Nb^{95} Nb^{97}				3.7×10^{3} 35 0.051	com- pared to 4 f rare earths)	787 33.8 0.051			0.47 0.39 0.38			
	Nb		Spleen 150 g 7 cm	$<10^{-6}$ (Ti-1 through Ti-7)		950			0.01 (Ha-26)		8×10^{-3} (Ha-26)	8×10^{-7}	2×10^{-3}
	Nb^{93m}				3.7×10^{3}		756			9.6×10^{-3}			
	Nb^{95}				35		33.8			8.2×10^{-3}			
	Nb^{97}				0.051		0.051			8×10^{-3}			
	Nb		Kidneys 300 g 7 cm	$<10^{-6}$ (Ti-1 through Ti-7)		760			0.02 (Ha-26)		0.02 (Ha-26)	2×10^{-6}	5×10^{-3}
	Nb^{93m}				3.7×10^{3}		640			0.02			
	Nb^{95}				35		33.5			0.02			
	Nb^{97}				0.051		0.051			0.02			
	Nb		Liver 1.7×10^{3} g 10 cm	$<10^{-6}$ (Ti-1 through Ti-7)		845			0.1 (Ha-26)		0.09 (Ha-26)	9×10^{-6}	0.02
	Nb^{93m}				3.7×10^{3}		688			0.1			
	Nb^{95}				35		33.6			0.09			
	Nb^{97}				0.051		0.051			0.09			
42	Mo	4.5×10^{-4} (Ti-3)	Total body 7×10^{4} g 30 cm	$<7\times10^{-8}$ (Ti-1 through Ti-7)		5		0.8 (Co-3 Co-4)	1.0 (D)		1.0 (D)	0.8	0.65
	Mo^{99}				2.79		1.8			1.0 (D)			
	Mo		Liver 1.7×10^{3} g 10 cm	1.1×10^{-6} (Ti-1 through Ti-7)		45			0.9 (Ti-1 through Ti-7)		0.1 (Bn-7 Bn-8)	0.08	0.065
	Mo^{99}				2.79		2.66			0.15			

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Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Mo		Kidneys 300 g 7 cm	4×10^{-7} (Ti-1 through Ti-7)		3			0.05 (Ti-1 through Ti-7)		0.08 (Bn-7 Bn-8)	0.06	0.05
	Mo^{99}				2.79		1.5			0.065			
43	Tc		Total body 7×10^4 g 30 cm			1 (Ha-21)		0.5 (Ha-21)	1.0 (D)		1.0 (D)	0.5	0.5
	Tc^{96m}				0.036		0.036			1.0 (D)			
	Tc^{96}				4.3		0.8			1.0 (D)			
	Tc^{97m}				92		0.99			1.0 (D)			
	Tc^{97}				3.7×10^6		1			1.0 (D)			
	Tc^{99m}				0.25		0.2			1.0 (D)			
	Tc^{99}				7.7×10^7		1			1.0 (D)			
	Tc		Kidneys 300 g 7 cm			20			0.2 (Ha-21)		0.01 (Ha-21)	5×10^{-3}	5×10^{-3}
	Tc^{96m}				0.036		0.036			0.01			
	Tc^{96}				4.3		3.5			0.04			
	Tc^{97m}				92		16			0.16			
	Tc^{97}				3.7×10^6		20			0.2			
	Tc^{99m}				0.25		0.25			0.01			
	Tc^{99}				7.7×10^7		20			0.2			
	Tc		Lungs 10^3 g 10 cm			5 (Ha-21)			4.5×10^{-3}		9×10^{-4} (Ha-21)	4.5×10^{-4}	4.5×10^{-4}

Tc^{96m}			0.036		0.036		9.2×10^{-4}			
Tc^{96}			4.3		2.3		2.6×10^{-3}			
Tc^{97m}			92		4.7		4.3×10^{-3}			
Tc^{97}			3.7×10^{6}		5		4.5×10^{-3}			
Tc^{99m}			0.25		0.24		1.1×10^{-3}			
Tc^{99}			7.7×10^{7}		5		4.5×10^{-3}			
Tc	Skin 2×10^{3} g 0.1 cm			10		0.1 (Ha-21)		0.01 (Ha-21)	5×10^{-3}	5×10^{-3}
Tc^{96m}			0.036		0.036		0.01			
Tc^{96}			4.3		3		0.04			
Tc^{97m}			92		9		0.09			
Tc^{97}			3.7×10^{6}		10		0.1			
Tc^{99m}			0.25		0.24		0.01			
Tc^{99}			7.7×10^{7}		10		0.1			
Tc	Liver 1.7×10^{3} g 10 cm			30		0.09 (Ha-21)		3×10^{-3} (Ha-21)	1.5×10^{-3}	1.5×10^{-3}
Tc^{96m}			0.036		0.036		3×10^{-3}			
Tc^{96}			4.3		3.8		0.01			
Tc^{97m}			92		23		0.07			
Tc^{97}			3.7×10^{6}		30		0.09			
Tc^{99m}			0.25		0.25		0.004			
Tc^{99}			7.7×10^{7}		30		0.09			
Tc	Bone 7×10^{3} g 5 cm			25		0.05 (Ha-21)		2×10^{-3} (Ha-21)	10^{-3}	10^{-3}
Tc^{96m}			0.036		0.036		2×10^{-3}			
Tc^{96}			4.3		3.7		9×10^{-3}			
Tc^{97m}			92		20		0.04			
Tc^{97}			3.7×10^{6}		25		0.05			
Tc^{99m}			0.25		0.25		2.5×10^{-3}			
Tc^{99}			7.7×10^{7}		25		0.05			

*Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
44	Ru		Total body 7×10^4 g 30 cm	$<8.6\times10^{-8}$ (Ti-1 through Ti-7)		7.3		0.03 (Kt-2 Th-20 Hy-3)	1.0 (D)		1.0 (D)	0.03	0.27
	Ru^{97}				2.8		2.0			1.0 (D)			
	Ru^{103}				41		6.2			1.0 (D)			
	Ru^{105}				0.19		0.19			1.0 (D)			
	Ru^{106}				365		7.2			1.0 (D)			
	Ru		Kidneys 300 g 7 cm	$<10^{-7}$ (Ti-1 through Ti-7)		2.5 (Hy-3)			0.07 (Hy-3 Ha-89)		0.2 (Hy-3)	6×10^{-3} (Hy-3)	0.05 (Hy-3)
	Ru^{97}				2.8		1.3			0.13			
	Ru^{103}				41		2.4			0.08			
	Ru^{105}				0.19		0.18			0.19			
	Ru^{106}				365		2.48			0.07			
	Ru		Bone 7×10^3 g 5 cm			16			0.17 (Bn-11)		0.08 (Bn-11)	2.4×10^{-3}	0.02
	Ru^{97}				2.8		2.4			0.095			
	Ru^{103}				41		12			0.15			
	Ru^{105}				0.19		0.19			0.08			
	Ru^{106}				365		15			0.17			
45	Rh		Total body			10.4		0.2	1.0		1.0	0.2	0.35

	Rh^{103m} Rh^{105}		7×10^4 g 30 cm		0.038 1.52		0.038 1.33	(compared to Co and Ir)	(D)	1.0 (D) 1.0 (D)	(D)			
	Rh Rh^{103m} Rh^{105}		Kidneys 300 g 7 cm		0.038 1.52	28 (Ha-89)	0.038 1.44		0.08 (Ha-85 Ha-89)	0.03 0.03	0.03 (Ha-89)	6×10^{-3}	0.01	
	Rh Rh^{103m} Rh^{105}		Spleen 150 g 7 cm		0.038 1.52	20.8	0.038 1.42		0.02 (Ha-85 Ha-89)	0.01 0.01	0.01 (Ha-89)	2×10^{-3}	3.5×10^{-3}	
	Rh Rh^{103m} Rh^{105}		Bone 7×10^3 g 5 cm		0.038 1.52	16.6	0.038 1.39		0.08 (Ha-85 Ha-89)	0.05 0.05	0.05 (Ha-89)	0.01	0.02	
	Rh Rh^{103m} Rh^{105}		Liver 1.7×10^3 g 10 cm		0.038 1.52	18.2	0.038 1.4		0.07 (Ha-85 Ha-89)	0.04 0.04	0.04 (Ha-89)	8×10^{-3}	0.014	
46	Pd Pd^{103} Pd^{109}		Total body 7×10^4 g 30 cm		17 0.57	5 (Ha-89)	3.9 0.51	0.2 (compared to Ni and Pt)	1.0 (D)	1.0 (D) 1.0 (D)	1.0 (D)	0.2	0.35	
	Pd Pd^{103} Pd^{109}		Kidneys 300 g 7 cm		17 0.57	30	11 0.56		0.48 (Ha-89)	0.23 0.09	0.08 (Ha-89)	0.02	0.03	

* Reference equations unless otherwise indicated.

Gen.* ref. / z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Pd		Liver 1.7×10^3 g 10 cm			19			0.34 (Ha-89)		0.09 (Ha-89)	0.02	0.03
	Pd^{103}				17		9			0.21			
	Pd^{109}				0.57		0.55			0.1			
	Pd		Spleen 150 g 7 cm			15			0.03 (Ha-89)		0.01 (Ha-89)	2×10^{-3}	3.5×10^{-3}
	Pd^{103}				17		8			0.02			
	Pd^{109}				0.57		0.55			0.01			
47	Ag	$<1.4\times10^{-8}$ (Ti-1 through Ti-7)	Total body 7×10^4g 30 cm	8.8×10^{-5} (Sun-1)		5		0.01 (Ha-96)	1.0 (D)		1.0 (D)	0.01	0.26
	Ag^{105}				40		4.4			1.0 (D)			
	Ag^{110m}				270		4.9			1.0 (D)			
	Ag^{111}				7.5		3			1.0 (D)			
	Ag		Bone 7×10^3 g 5 cm	$<10^{-7}$ (Ti-1 through Ti-7)		30			0.3 (Ha-96)		0.05 (Ha-96)	5×10^{-4}	0.013
	Ag^{105}				40		17			0.19			
	Ag^{110m}				270		27			0.28			
	Ag^{111}				7.5		6			0.1			

	Ag		Liver 1.7×10^{3} g 10 cm	1.8×10^{-8} (Ti-1 through Ti-7)		15			0.09 (Ha-96)		0.03 (Ha-96)	3×10^{-4}	7.7×10^{-3}
	Ag^{105}				40		11			0.075			
	Ag^{110m}				270		14.2			0.09			
	Ag^{111}				7.5		5			0.05			
	Ag		Kidneys 300 g 7 cm	$<10^{-8}$ (Ti-1 through Ti-7)		10			0.04 (Ha-96)		0.02 (Ha-96)	2×10^{-4}	5×10^{-3}
	Ag^{105}				40		8			0.04			
	Ag^{110m}				270		10			0.04			
	Ag^{111}				7.5		4			0.03			
48	Cd		Total body 7×10^{4} g 30 cm	4.3×10^{-7} (Ti-1 through Ti-7)		200		$<2.5\times10^{-3}$ (Ha-101)	1.0 (D)		1.0 (D)	2.5×10^{-3}	0.25
	Cd^{109}				475		140			1.0 (D)			
	Cd^{115m}				43		35			1.0 (D)			
	Cd^{115}				2.2		2.2			1.0 (D)			
	Cd		Kidneys 300 g 7 cm	3.2×10^{-5} (Ti-1 through Ti-7)		300			0.15 (Ha-101)		0.1 (Ha-21 Ha-101)	2.5×10^{-4}	0.025
	Cd^{109}				475		184			0.13			
	Cd^{115m}				43		38			0.11			
	Cd^{115}				2.2		2.2			0.1			
	Cd		Liver 1.7×10^{3} g 10 cm	2.4×10^{-6} (Ti-1 through Ti-7)		200 (Ha-21)			0.76 (Ha-101)		0.75 (Ha-21 Ha-101)	1.9×10^{-3}	0.19
	Cd^{109}				475		140			0.76			
	Cd^{115m}				43		35			0.75			
	Cd^{115}				2.2		2.2			0.76			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
49	In		Total body 7×10^4 g 30 cm			48		$<2\times10^{-3}$ (Ha-19 Ha-101)	1.0 (D)		1.0 (D)	2×10^{-3}	0.25
	In^{113m}				0.073		0.073			1.0 (D)			
	In^{114m}				49		24			1.0 (D)			
	In^{115m}				0.19		0.19			1.0 (D)			
	In^{115}				2.2×10^{17}		48			1.0 (D)			
	In		Kidneys 300 g 7 cm			60			0.05 (Ha-19)		0.04 (Ha-19 Ha-101)	8×10^{-5}	0.01
	In^{113m}				0.073		0.073			0.04			
	In^{114m}				49		27			0.045			
	In^{115m}				0.19		0.19			0.04			
	In^{115}				2.2×10^{17}		60			0.05			
	In		Spleen 150 g 7 cm			48 (Ha-19)			0.02 (Ha-19)		0.02 (Ha-19 Ha-101)	4×10^{-5}	5×10^{-3}
	In^{113m}				0.073		0.073			0.02			
	In^{114m}				49		24			0.02			
	In^{115m}				0.19		0.19			0.02			
	In^{115}				2.2×10^{17}		48			0.02			

	In		Liver 1.7×10^3 g 10 cm			58			0.17 (Ha-19)		0.14 (Ha-19 Ha-101)	2.8×10^{-4}	0.04
	In^{113m}				0.073		0.073			0.14			
	In^{114m}				49		26			0.15			
	in^{115m}				0.19		0.19			0.14			
	In^{115}				2.2×10^{17}		58			0.17			
	In		Skin 2×10^3 g 0.1 cm			67			0.25 (Ha-19)		0.18 (Ha-19)	3.6×10^{-4}	0.05
	In^{113m}				0.073		0.073			0.18			
	In^{114m}				49		26			0.21			
	In^{115m}				0.19		0.19			0.18			
	In^{115}				2.2×10^{17}		67			0.25			
	In		Bone 7×10^3 g 5 cm			57			0.2 (Ha-19)		0.17 (Ha-19 Ha-101)	3.4×10^{-4}	0.04
	In^{113m}				0.073		0.073			0.17			
	In^{114m}				49		26			0.18			
	In^{115m}				0.19		0.19			0.17			
	In^{115}				2.2×10^{17}		57			0.2			
	In		Thyroid 20 g 3 cm			8.4			7×10^{-5} (Ha-19)		4×10^{-4} (Ha-19)	8×10^{-7}	10^{-4}
	In^{113m}				0.073		0.073			4×10^{-4}			
	In^{114m}				49		7.2			1.2×10^{-4}			
	In^{115m}				0.19		0.19			4×10^{-4}			
	In^{115}				2.2×10^{17}		8.4			7×10^{-5}			
50	Sn	0.017 (Sun-3)	Total body 7×10^4 g 30 cm	4.3×10^{-7} (Ti-1 through Ti-7)		35		0.05 (Sun-3 Kn-2 G)	1.0 (D)		1.0 (D)	0.05	0.28
	Sn^{113}				112		27			1.0 (D)			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radio-nuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concen-tration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Bio-logical T_b	Effective T		Element	Radio-nuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Sn^{125}				9.5		7.5			1.0 (D)			
	Sn		Bone 7×10^3 g 5 cm	$<1.3\times10^{-6}$ (Ti-1 through Ti-7)		100 (Ha-18)			0.86 (Ha-18 Ha-20)		0.3 (Ha-18)	0.02	0.08
	Sn^{113}				112		53			0.59			
	Sn^{125}				9.5		8.7			0.35			
	Sn		Thyroid 20 g 3 cm	2.8×10^{-7} (Ti-1 through Ti-7)		70			2×10^{-4} (Ha-18 Ha-20)		10^{-4}	5×10^{-6}	2.8×10^{-5}
	Sn^{113}				112		43			1.6×10^{-4}			
	Sn^{125}				9.5		8.4			10^{-4}			
	Sn		Liver 1.7×10^3 g 10 cm	4×10^{-7} (Ti-1 through Ti-7)		70			0.02 (Ha-18 Ha-20)		0.01 (Ha-18)	5×10^{-4}	2.8×10^{-3}
	Sn^{113}				112		43			0.02			
	Sn^{125}				9.5		8.4			0.01			
	Sn		Prostate 40 g 3 cm	3×10^{-7} (Ti-1 through Ti-7)		35			1.6×10^{-3} (Ha-18 Ha-20)		1.6×10^{-3} (Ha-18)	8×10^{-5}	4.4×10^{-4}
	Sn^{113}				112		27			1.6×10^{-3}			
	Sn^{125}				9.5		7.5			1.6×10^{-3}			

51	Sb		Total body 7×10^4 g 30 cm	$<1.3 \times 10^{-6}$ (Ti-1 through Ti-7)		38 (Ha-19)		0.03 (Ha-19)	1.0 (D)		1.0 (D)	0.03	0.27
	Sb^{122}				2.8		2.6			1.0 (D)			
	Sb^{124}				60		23			1.0 (D)			
	Sb^{125}				876		36			1.0 (D)			
	Sb		Bone 7×10^3 g 5 cm	2×10^{-7} (Led-1)		100			0.26 (Ha-19)		0.1 (Ha-19)	3×10^{-3}	0.03
	Sb^{122}				2.8		2.7			0.1			
	Sb^{124}				60		38			0.16			
	Sb^{125}				876		90			0.25			
	Sb		Lungs 10^3 g 10 cm	10^{-7} (Led-1)		100			0.08 (Ha-19)		0.03 (Ha-19)	9×10^{-4}	8×10^{-3}
	Sb^{122}				2.8		2.7			0.03			
	Sb^{124}				60		38			0.05			
	Sb^{125}				876		90			0.07			
	Sb		Thyroid 20 g 3 cm	$<3 \times 10^{-6}$ (Ti-1 through Ti-7)		4			3×10^{-6} (Ha-19)		3×10^{-5} (Ha-19)	9×10^{-7}	8×10^{-6}
	Sb^{122}				2.8		1.6			2×10^{-5}			
	Sb^{124}				60		3.8			5×10^{-6}			
	Sb^{125}				876		4			3×10^{-6}			
	Sb		Liver 1.7×10^3 g 10 cm	2×10^{-7} (Led-1)		38			2×10^{-3} (Ha-19)		2×10^{-3} (Ha-19)	6×10^{-5}	5×10^{-4}

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of Reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Sb^{122}				2.8		2.6			2×10^{-3}			
	Sb^{124}				60		23			2×10^{-3}			
	Sb^{125}				876		36			2×10^{-3}			
52	Te		Total body 7×10^4 g 30 cm			15		0.25 (Ha-9)	1.0 (D)		1.0 (D)	0.25	0.38
	Te^{125m}				58		12			1.0 (D)			
	Te^{127m}				105		13			1.0 (D)			
	Te^{127}				0.39		0.38			1.0 (D)			
	Te^{129m}				33		10			1.0 (D)			
	Te^{129}				0.051		0.051			1.0 (D)			
	Te^{131m}				1.25		1.15			1.0 (D)			
	Te^{132}				3.2		2.6			1.0 (D)			
	Te		Kidneys 300 g 7 cm			30			0.14 (Ha-26)		0.07 (Ha-26)	0.02	0.03
	Te^{125m}				58		20			0.12			
	Te^{127m}				105		23			0.12			

Te^{127}			0.39		0.39		0.07			
Te^{129m}			33		16		0.11			
Te^{129}			0.051		0.051		0.07			
Te^{131m}			1.25		1.2		0.07			
Te^{132}			3.2		2.9		0.07			
Te	Spleen 150 g 7 cm			30 (Ha-26)		0.02 (Ha-26)		0.01 (Ha-26)	2.5×10^{-3}	3.8×10^{-3}
Te^{125m}			58		20		0.02			
Te^{127m}			105		23		0.02			
Te^{127}			0.39		0.39		0.01			
Te^{129m}			33		16		0.02			
Te^{129}			0.051		0.051		0.01			
Te^{131m}			1.25		1.2		0.01			
Te^{132}			3.2		2.9		0.01			
Te	Bone 7×10^{3} g 5 cm	3×10^{-4} (Led-1)		30 (Ha-26)		0.18 (Ha-9 Ha-26)		0.09 (Ha-9 Ha-26)	0.023	0.034
Te^{125m}			58		20		0.15			
Te^{127m}			105		23		0.16			
Te^{127}			0.39		0.39		0.09			
Te^{129m}			33		16		0.14			
Te^{129}			0.051		0.051		0.09			
Te^{131m}			1.25		1.2		0.09			
Te^{132}			3.2		2.9		0.1			
Te	Liver 1.7×10^{3} g 10 cm	10^{-3} (Led-1)		30		0.1 (Ha-9 Ha-26)		0.05 (Ha-9 Ha-26)	0.01	0.02
Te^{125m}			58		20		0.08			
Te^{127m}			105		23		0.09			
Te^{127}			0.39		0.39		0.05			
Te^{129m}			33		16		0.08			
Te^{129}			0.051		0.051		0.05			
Te^{131m}			1.25		1.2		0.05			
Te^{132}			3.2		2.9		0.06			
Te	Thyroid			9		6×10^{-4}		10^{-3}	2.5×10^{-4}	3.8×10^{-4}

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
			20 g 3 cm						(Ha-9 Ha-26)		(Ha-9 Ha-26)		
	Te^{125m}				58		7.8			6.5×10^{-4}			
	Te^{127m}				105		8.3			6×10^{-4}			
	Te^{127}				0.39		0.37			9.7×10^{-4}			
	Te^{129m}				33		7.1			7×10^{-4}			
	Te^{129}				0.051		0.051			10^{-3}			
	Te^{131m}				1.25		1.1			9.6×10^{-4}			
	Te^{132}				3.2		2.4			10^{-3}			
	Te		Testes 40 g 3 cm	3×10^{-4} (Led-1)		30			6×10^{-3} (Ja-2)		3×10^{-3} (Ja-2)	7.5×10^{-4}	1.1×10^{-3}
	Te^{125m}				58		20			5×10^{-3}			
	Te^{127m}				105		23			5×10^{-3}			
	Te^{127}				0.39		0.39			3×10^{-3}			
	Te^{129m}				33		16			5×10^{-3}			
	Te^{129}				0.051		0.051			3×10^{-3}			
	Te^{131m}				1.25		1.2			3×10^{-3}			
	Te^{132}				3.2		2.9			3×10^{-3}			

53	I	2×10^{-4} (Un-1)	Total body 7×10^{4} g 30 cm	5.7×10^{-7} (Ch-1)		138		1.0 (Un-1)	1.0 (D)		1.0 (D)	1.0	0.75
	I^{126}				13.3		12.1			1.0 (D)			
	I^{129}				6.3×10^{9}		138			1.0 (D)			
	I^{131}				8		7.6			1.0 (D)			
	I^{132}				0.097		0.097			1.0 (D)			
	I^{133}				0.87		0.87			1.0 (D)			
	I^{134}				0.036		0.036			1.0 (D)			
	I^{135}				0.28		0.28			1.0 (D)			
	I		Thyroid 20 g 3 cm	4×10^{-4} (Ev-1)		138 (eq. 48)			0.2 (Ev-1)		0.3 (Goo-1 Lar-1 Ke-2)	0.3	0.23
	I^{126}				13.3		12.1			0.2			
	I^{129}				6.3×10^{9}		138			0.2			
	I^{131}				8		7.6			0.2			
	I^{132}				0.097		0.097			0.2			
	I^{133}				0.87		0.87			0.2			
	I^{134}				0.036		0.036			0.2			
	I^{135}				0.28		0.28			0.2			
	I		Kidneys 300 g 7 cm			7			0.002 (Ho-5 Ho-10)		0.04 (Ho-5 Ho-10)	0.04	0.03
	I^{126}				13.3		4.58			0.015			
	I^{129}				6.3×10^{9}		7			0.002			
	I^{131}				8		3.73			0.02			
	I^{132}				0.097		0.096			0.04			
	I^{133}				0.87		0.77			0.035			
	I^{134}				0.036		0.035			0.04			
	I^{135}				0.28		0.27			0.05			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radio-nuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concen-tration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Bio-logical T_b	Effective T		Element	Radio-nuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	I		Liver 1.7×10^3 g 10 cm			7			0.006 (Ho-5 Ho-10)		0.12 (Ho-5 Ho-10)	0.12	0.09
	I^{126}				13.3		4.58			0.045			
	I^{129}				6.3×10^9		7			0.006			
	I^{131}				8		3.73			0.06			
	I^{132}				0.097		0.096			0.12			
	I^{133}				0.87		0.77			0.11			
	I^{134}				0.036		0.035			0.12			
	I^{135}				0.28		0.27			0.12			
	I		Spleen 150 g 7 cm			7			2.5×10^{-4} (Ho-5 Ho-10)		5×10^{-3} (Ho-5 Ho-10)	5×10^{-3}	3.8×10^{-3}
	I^{126}				13.3		4.58			0.002			
	I^{129}				6.3×10^9		7			0.0025			
	I^{131}				8		3.73			0.0025			
	I^{132}				0.097		0.096			0.005			
	I^{133}				0.87		0.77			0.004			
	I^{134}				0.036		0.035			0.005			
	I^{135}				0.28		0.27			0.005			
	I		Testes 40 g 3 cm			7			2.5×10^{-4} (Ho-5 Ho-10)		5×10^{-3} (Ho-5 Ho-10)	5×10^{-3}	0.0038
	I^{126}				13.3		4.58			0.002			

	I^{129}				6.3×10^{9}		7			2.5×10^{-4}			
	I^{131}				8		3.73			2.5×10^{-3}			
	I^{132}				0.097		0.096			0.005			
	I^{133}				0.87		0.77			0.004			
	I^{134}				0.036		0.035			0.005			
	I^{135}				0.28		0.27			0.005			
	I		Bone 7×10^{3} g 5 cm			14			0.007 (Ho-5 Ho-10)		0.07 (Ho-5 Ho-10)	0.07	0.053
	I^{126}				13.3		6.8			0.04			
	I^{129}				6.3×10^{9}		14			0.007			
	I^{131}				8		5.1			0.13			
	I^{132}				0.097		0.096			0.07			
	I^{133}				0.87		0.82			0.067			
	I^{134}				0.036		0.036			0.07			
	I^{135}				0.28		0.27			0.068			
54	Xe		Total body 7×10^{4} g 30 cm					1.0 (G)	1.0 (D)		1.0 (D)	1.0	0.75
	Xe^{131m}				12					1.0 (D)			
	Xe^{133}				5.27					1.0 (D)			
	Xe^{135}				0.38					1.0 (D)			
55	Cs		Total body 7×10^{4} g 30 cm	$<1.4\times10^{-10}$ (Ti-1 through Ti-7)		70		1.0 (Ha-1 Kt-2)	1.0 (D)		1.0 (D)	1.0	0.75
	Cs^{131}				10		8.75			1.0 (D)			
	Cs^{134m}				0.13		0.13			1.0 (D)			
	Cs^{134}				840		65			1.0 (D)			
	Cs^{135}				1.1×10^{9}		70			1.0 (D)			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction of organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Cs^{136}				13		11			1.0 (D)			
	Cs^{137}				1.1×10^{4}		70			1.0 (D)			
	Cs		Muscle 3×10^{4} g 30 cm	$<3\times10^{-7}$ (Ti-1 through Ti-7)		140 (Ln-18 Rh-1)			0.8 (Ha-26 Rh-1)		0.4 (Ha-26)	0.4	0.3
	Cs^{131}				10		9.3			0.43			
	Cs^{134m}				0.13		0.13			0.40			
	Cs^{134}				840		120			0.74			
	Cs^{135}				1.1×10^{9}		140			0.80			
	Cs^{136}				13		11.9			0.43			
	Cs^{137}				1.1×10^{4}		138			0.79			
	Cs		Lungs 10^{3} g 10 cm	4×10^{-7} (Led-1)		140			6×10^{-3} (Ha-26)		3×10^{-3} (Ha-26)	3×10^{-3}	2.3×10^{-3}
	Cs^{131}				10		9.3			3×10^{-3}			
	Cs^{134m}				0.13		0.13			3×10^{-3}			
	Cs^{134}				840		120			6×10^{-3}			
	Cs^{135}				1.1×10^{9}		140			6×10^{-3}			
	Cs^{136}				13		11.9			3×10^{-3}			
	Cs^{137}				1.1×10^{4}		138			6×10^{-3}			
	Cs		Kidneys 300 g 7 cm	3×10^{-7} (Led-1)		42			6×10^{-3} (Ha-26)		0.01 (Ha-26)	0.01	7.5×10^{-3}

	Cs^{131}				10		8			9×10^{-3}			
	Cs^{134m}				0.13		0.13			0.01			
	Cs^{134}				840		40			6×10^{-3}			
	Cs^{135}				1.1×10^{9}		42			6×10^{-3}			
	Cs^{136}				13		10			9×10^{-3}			
	Cs^{137}				1.1×10^{4}		42			6×10^{-3}			
	Cs		Spleen 150 g 7 cm	6×10^{-7} (Led-1)		98			7×10^{-3} (Ha-26)		5×10^{-3} (Ha-26)	5×10^{-3}	3.8×10^{-3}
	Cs^{131}				10		9.1			5×10^{-3}			
	Cs^{134m}				0.13		0.13			5×10^{-3}			
	Cs^{134}				840		88			7×10^{-3}			
	Cs^{135}				1.1×10^{9}		98			7×10^{-3}			
	Cs^{136}				13		11.5			5×10^{-3}			
	Cs^{137}				1.1×10^{4}		97			7×10^{-3}			
	Cs		Liver 1.7×10^{3} g 10 cm	6×10^{-7} (Led-1)		90			0.09 (Ha-26)		0.07 (Ha-26)	0.07	0.05
	Cs^{131}				10		9			0.07			
	Cs^{134m}				0.13		0.13			0.07			
	Cs^{134}				840		81			0.09			
	Cs^{135}				1.1×10^{9}		90			0.09			
	Cs^{136}				13		11.4			0.07			
	Cs^{137}				1.1×10^{4}		89			0.09			
	Cs		Bone 7×10^{3} g 5 cm	6×10^{-6} (Led-1)		140			0.08 (Ha-26)		0.04 (Ha-26)	0.04	0.03
	Cs^{131}				10		9.3			0.04			
	Cs^{134m}				0.13		0.13			0.04			
	Cs^{134}				840		120			0.07			
	Cs^{135}				1.1×10^{9}		140			0.08			
	Cs^{136}				13		11.9			0.04			
	Cs^{137}				1.1×10^{4}		138			0.08			
56	Ba	9×10^{-4} (Ti-3)	Total body 7×10^{4} g 30 cm	2.3×10^{-7} (Ti-1 through		65		0.05 (Pit-1 Har-4)	1.0 (D)		1.0 (D)	0.05	0.28

* Reference equations unless otherwise indicated.

Gen.* ref. / z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Ba^{131}			Ti-7)	11.6		9.8			1.0 (D)			
	Ba^{140}				12.8		10.7			1.0 (D)			
	Ba		Bone 7×10^3 g 5 cm	1.6×10^{-6} (Ti-1 through		65 (Ha-51 eq. 48)			0.7 (Ha-51 Ti-1		0.7 (Do-1)	0.035	0.19
	Ba^{131}			Ti-7)	11.6		9.8		through Ti-7)	0.7			
	Ba^{140}				12.8		10.7			0.7			
	Ba		Lungs 10^3 g 10 cm	1.8×10^{-7} (Ti-1 through		6500			0.02 (Ti-1 through		2×10^{-4} (Ha-51)	10^{-5}	5.5×10^{-5}
	Ba^{131}			Ti-7)	11.6		11.6		Ti-7)	2.4×10^{-4}			
	Ba^{140}				12.8		12.8			2.4×10^{-4}			
	Ba		Muscle 3×10^4 g 30 cm	1.8×10^{-8} (Ti-1 through		2000			0.09 (Ti-1 through		3×10^{-3} (Ha-51)	1.5×10^{-4}	8.3×10^{-4}
	Ba^{131}			Ti-7)	11.6		11.5		Ti-7)	3.5×10^{-3}			
	Ba^{140}				12.8		12.7			3.6×10^{-3}			
	Ba		Kidneys 300 g 7 cm	2.7×10^{-8} (Ti-1 through		8.5			1.3×10^{-5}		10^{-4} (Ha-51)	5×10^{-6}	2.8×10^{-5}

	Ba^{131} Ba^{140}			Ti-7)	11.6 12.8		4.9 5.1		(Ti-1 through Ti-7)	5×10^{-5} 5×10^{-5}			
	Ba Ba^{131} Ba^{140}		Spleen 150 g 7 cm	$<2.2\times10^{-8}$ (Ti-1 through Ti-7)	 11.6 12.8	13	 6.1 6.4		10^{-5} (Ti-1 through Ti-7)	 3×10^{-5} 3×10^{-5}	5×10^{-5} (Ha-51)	2.5×10^{-6}	1.4×10^{-5}
	Ba Ba^{131} Ba^{140}		Liver 1.7×10^{3} g 10 cm	$<1.3\times10^{-8}$ (Ti-1 through Ti-7)	 11.6 12.8	975	 11.5 12.6		9×10^{-3} (Ti-1 through Ti-7)	 7×10^{-4} 7×10^{-4}	6×10^{-4} (Ha-51)	3×10^{-5}	1.7×10^{-4}
	Ba Ba^{131} Ba^{140}		Testes 40 g 3 cm	10^{-8} (Ti-1 through Ti-7)	 11.6 12.8	6.2	 4.1 4.2		9.6×10^{-5} (Ti-1 through Ti-7)	 4×10^{-4} 4×10^{-4}	10^{-3} (Ha-51)	5×10^{-5}	2.8×10^{-4}
	Ba Ba^{131} Ba^{140}		Ovaries 8 g 3 cm	4×10^{-8} (Ti-1 through Ti-7)	 11.6 12.8	4.9	 3.4 3.5		3×10^{-5} (Ti-1 through Ti-7)	 1.4×10^{-4} 1.3×10^{-4}	4×10^{-4} (Ha-51)	2×10^{-5}	10^{-4}
57	La La^{140}		Total body 7×10^{4} g 30 cm	$<7\times10^{-7}$ (Ti-1 through Ti-7)	 1.68	500	 1.68	$<10^{-4}$ (Ha-55)	1.0 (D)	 1.0 (D)	1.0 (D)	10^{-4}	0.25
	La La^{140}		Bone 7×10^{3} g 5 cm		 1.68	1000 (Ha-55)	 1.68		0.8 (Ha-9 Ha-10)	 0.4	0.4 (Ha-9)	4×10^{-5}	0.1
	La		Liver	$<10^{-6}$		400			0.12		0.15	1.5×10^{-5}	0.04

* Reference equations unless otherwise indicated.

Gen.* ref.	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_s
z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
			1.7×10^3 g 10 cm	(Ti-1 through Ti-7)					(Ha-9 Ha-10)		(Ha-9)		
	La^{140}				1.68		1.68			0.15			
58	Ce		Total body 7×10^4 g 30 cm			563		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Ce^{141}				32		30			1.0 (D)			
	Ce^{143}				1.33		1.33			1.0 (D)			
	Ce^{144}				290		191			1.0 (D)			
	Ce		Bone 7×10^3 g 5 cm			1500 (Ha-55)			0.8 (Ha-33 Ha-36 Ha-86)		0.3 (At-2 Ha-33 Ha-36 Ha-86)	3×10^{-5}	0.075
	Ce^{141}				32		31			0.31			
	Ce^{143}				1.33		1.33			0.30			
	Ce^{144}				290		243			0.38			
	Ce		Liver 1.7×10^3 g 10 cm			293			0.13 (Ha-33 (Ha-36 Ha-86)		0.25 (At-2 Ha-33 Ha-36 Ha-86)	2.5×10^{-5}	0.06
	Ce^{141}				32		29			0.24			
	Ce^{143}				1.33		1.32			0.25			
	Ce^{144}				290		146			0.19			
	Ce		Kidneys 300 g 7 cm			563			0.02 (Ha-33 Ha-36 Ha-86)		0.02 (At-2 Ha-33 Ha-36 Ha-86)	2×10^{-6}	5×10^{-3}
	Ce^{141}				32		30			0.02			
	Ce^{143}				1.33		1.33			0.02			
	Ce^{144}				290		191			0.02			

59	Pr		Total body 7×10^4 g 30 cm			750		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Pr^{142}				0.8		0.8			1.0			
	Pr^{143}				13.7		13.5			(D) 1.0 (D)			
	Pr		Bone 7×10^3 g 5 cm			1500 (Ha-55)			0.8 (Ha-33 Ha-36 Ha-86)		0.4 (Ha-33) Ha-36 Ha-86)	4×10^{-5}	0.1
	Pr^{142}				0.8		0.8			0.4			
	Pr^{143}				13.7		13.6			0.4			
	Pr		Liver 1.7×10^3 g 10 cm			375			0.1 (Ha-33 Ha-36 Ha-86)		0.2 (Ha-33) Ha-36 Ha-86)	2×10^{-5}	0.05
	Pr^{142}				0.8		0.8			0.2			
	Pr^{143}				13.7		13.2			0.2			
	Pr		Kidneys 300 g 7 cm			750			0.02 (Ha-33) Ha-36 Ha-86)		0.02 (Ha-33 Ha-36 Ha-86)	2×10^{-6}	5×10^{-3}
	Pr^{142}				0.8		0.8			0.02			
	Pr^{143}				13.7		13.5			0.02			
60	Nd		Total body 7×10^4 g 30 cm			656		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	$<10^{-4}$	0.25
	Nd^{144}				7.3×10^{17}		656			1.0			
	Nd^{147}				11.3		11.1			(D) 1.0			
	Nd^{149}				0.083		0.083			(D) 1.0 (D)			
	Nd		Bone 7×10^3 g 5 cm			1500 (Ha-55)			0.8 (Ha-32 Ha-33 Ha-36 Ha-86)		0.35 (Ha-33 Ha-36 Ha-48 Ha-86)	3.5×10^{-5}	0.09
	Nd^{144}				7.3×10^{17}		1500			0.8			
	Nd^{147}				11.3		11.2			0.35			
	Nd^{149}				0.083		0.083			0.35			
	Nd		Liver 1.7×10^3 g 10 cm			131			0.1 (Ha-33 Ha-36		0.5 (Ha-33 Ha-36	5×10^{-5}	0.13
	Nd^{144}				7.3×10^{17}		131			0.1			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days) Physical T_r	Half-life (days) Biological T_b	Half-life (days) Effective T	Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2 Element	Fraction in organ of reference of that in total body f_2 Radionuclide	Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference By ingestion f_w	Fraction reaching organ of reference By inhalation f_s
Z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Nd^{147} Nd^{149}				11.3 0.083		10 0.083		Ha-86)	0.45 0.5	Ha-48 Ha-86)		
	Nd Nd^{144} Nd^{147} Nd^{149}		Kidneys 300 g 7 cm		7.3×10^{17} 11.3 0.083	656	656 11.1 0.083		0.05 (Ha-33 Ha-36 Ha-86)	0.05 0.05 0.05	0.05 (Ha-33 Ha-36 Ha-48, Ha-86)	5×10^{-6}	0.01
61	Pm Pm^{147} Pm^{149}		Total body 7×10^{4} g 30 cm		 920 2.2	656	 383 2.2	$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)	 1.0 (D) 1.0 (D)	1.0 (D)	10^{-4}	0.25
	Pm Pm^{147} Pm^{149}		Bone 7×10^{3} g 5 cm		 920 2.2	1500 (Ha-55)	 570 2.2		0.8 (Ha-36 Ha-55 Ha-62)	 0.52 0.35	0.35 (Ha-33 Ha-36 Ha-86)	3.5×10^{-5}	0.09
	Pm Pm^{147} Pm^{149}		Liver 1.7×10^{3} g 10 cm		 920 2.2	656	 383 2.2		0.06 (Ha-36 Ha-55 Ha-62)	 0.06 0.06	0.06 (Ha-33 Ha-36 Ha-86)	6×10^{-6}	0.02
	Pm Pm^{147} Pm^{149}		Kidneys 300 g 7 cm		 920 2.2	656	 383 2.2		0.02 (Ha-36 Ha-55 Ha-62)	 0.02 0.02	0.02 (Ha-33 Ha-36 Ha-86)	2×10^{-6}	5×10^{-3}

62	Sm		Total body 7×10^4 g 30 cm			656		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Sm^{147}				4.8×10^{13}		656			1.0 (D)			
	Sm^{151}				3.7×10^4		645			1.0 (D)			
	Sm^{153}				1.96		1.95			1.0 (D)			
	Sm		Bone 7×10^3 g			1500 (Ha-55)			0.8 (Ha-18		0.35 (Ha-18	3.5×10^{-5}	0.09
	Sm^{147}		5 cm		4.8×10^{13}		1500		Ha-33)	0.8	Ha-33)		
	Sm^{151}				3.7×10^4		1442			0.78			
	Sm^{153}				1.96		1.96			0.35			
	Sm		Liver 1.7×10^3 g			187			0.1 (Ha-18		0.35 (Ha-18	3.5×10^{-5}	0.09
	Sm^{147}		10 cm		4.8×10^{13}		187		Ha-33)	0.1	Ha-33)		
	Sm^{151}				3.7×10^4		186			0.1			
	Sm^{153}				1.96		1.94			0.35			
	Sm		Kidneys 300 g			656			0.02 (Ha-18		0.02 (Ha-18	2×10^{-6}	5×10^{-3}
	Sm^{147}		7 cm		4.8×10^{13}		656		Ha-33)	0.02	Ha-33)		
	Sm^{151}				3.7×10^4		645			0.02			
	Sm^{153}				1.96		1.95			0.02			
63	Eu		Total body 7×10^4 g			635		$<10^{-4}$ (Ha-36	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Eu^{152}		30 cm		0.38		0.38	Ha-55)		1.0 (D)			
	Eu^{152}				4.7×10^3		559			1.0 (D)			
	Eu^{154}				5.8×10^3		572			1.0 (D)			
	Eu^{155}				621		314			1.0 (D)			

* Reference equations unless otherwise indicated.

Gen.* ref. / z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Eu		Bone 7×10^3 g 5 cm			1500 (Ha-55)			0.85 (Ha-33 Ha-36)		0.36 (Ha-33 Ha-36)	3.6×10^{-5}	0.09
	Eu^{152}				0.38		0.38			0.36			
	Eu^{152}				4.7×10^3		1137			0.73			
	Eu^{154}				5.8×10^3		1192			0.75			
	Eu^{155}				621		439			0.50			
	Eu		Kidneys 300 g 7 cm			1480			0.07 (Ha-33 Ha-36)		0.03 (Ha-33 Ha-36)	3×10^{-6}	7.5×10^{-3}
	Eu^{152}				0.38		0.38			0.03			
	Eu^{152}				4.7×10^3		1125			0.06			
	Eu^{154}				5.8×10^3		1180			0.06			
	Eu^{155}				621		438			0.04			
	Eu		Liver 1.7×10^3 g 10 cm			127			0.05 (Ha-33 Ha-36)		0.25 (Ha-33 Ha-36)	2.5×10^{-5}	0.06
	Eu^{152}				0.38		0.38			0.25			
	Eu^{152}				4.7×10^3		124			0.06			
	Eu^{154}				5.8×10^3		124			0.05			
	Eu^{155}				621		105			0.08			
64	Gd		Total body 7×10^4 g 30 cm			550		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Gd^{153}				236		165			1.0 (D)			
	Gd^{159}				0.75		0.75			1.0 (D)			
	Gd		Bone 7×10^3 g 5 cm			1000 (Ha-55)			0.8 (Ha-34 Ha-36)		0.45 (Ha-34 Ha-36)	4.5×10^{-5}	0.11

	Gd^{153} Gd^{159}				236 0.75		191 0.75			0.52 0.45			
	Gd Gd^{153} Gd^{159}		Liver 1.7×10^3 g 10 cm		 236 0.75	460	 156 0.75		0.1 (Ha-34 Ha-36)	 0.11 0.12	0.12 (Ha-34 Ha-36)	1.2×10^{-5}	0.03
65	Tb Tb^{160}		Total body 7×10^4 g 30 cm		 73	670	 66	$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)	 1.0 (D)	1.0 (D)	10^{-4}	0.25
	Tb Tb^{160}		Bone 7×10^3 g 5 cm		 73	1000 (Ha-55)	 68		0.9 (Ha-31 Ha-34 Ha-36)	 0.62	0.6 (Ha-34 Ha-36)	6×10^{-5}	0.15
	Tb Tb^{160}		Kidneys 300 g 7 cm		 73	700	 66		0.03 (Ha-31 Ha-34 Ha-36)	 0.03	0.03 (Ha-34 Ha-36)	3×10^{-6}	7.5×10^{-3}
66	Dy Dy^{165} Dy^{166}		Total body 7×10^4 g 30 cm		 0.097 3.4	700	 0.097 3.4	$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)	 1.0 (D) 1.0 (D)	1.0 (D)	10^{-4}	0.25
	Dy Dy^{165} Dy^{166}		Bone 7×10^3 g 5 cm		 0.097 3.4	1000 (Ha-55)	 0.097 3.4		0.85 (Ha-33 Ha-36)	 0.6 0.6	0.6 (Ha-33 Ha-36)	6×10^{-5}	0.15
	Dy Dy^{165} Dy^{166}		Liver 1.7×10^3 g 10 cm		 0.097 3.4	500	 0.097 3.4		0.04 (Ha-33 Ha-36)	 0.06 0.06	0.06 (Ha-33 Ha-36)	6×10^{-6}	0.02

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radio-nuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concen-tration, C (g/g wet tissues)	Half-life (days) Physical T_r	Bio-logical T_b	Effective T	Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2 Element	Radio-nuclide	Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
67	Ho		Total body 7×10^4 g 30 cm			750		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Ho^{166}				1.1		1.1			1.0 (D)			
	Ho		Bone 7×10^3 g 5 cm			1000 (Ha-55)			0.85 (Ha-33 Ha-36 Ha-86)		0.64 (Ha-33, Ha-36 Ha-48, Ha-86)	6.4×10^{-5}	0.16
	Ho^{166}				1.1		1.1			0.64			
	Ho		Kidneys 300 g 7 cm			800			0.02 (Ha-33 Ha-36 Ha-86)		0.02 (Ha-33, Ha-36 Ha-48, Ha-86)	2×10^{-6}	5×10^{-3}
	Ho^{166}				1.1		1.1			0.02			
	Ho		Liver 1.7×10^3 g 10 cm			875			0.07 (Ha-33 Ha-36 Ha-86)		0.06 (Ha-33, Ha-36 Ha-48, Ha-86)	6×10^{-6}	0.02
	Ho^{166}				1.1		1.1			0.06			
68	Er		Total body 7×10^4 g 30 cm			650		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Er^{169}				9.4		9.3			1.0 (D)			
	Er^{171}				0.31		0.31			1.0 (D)			

	Er		Bone 7×10^3 g 5 cm			1000 (Ha-55)			0.92 (Ha-36)		0.6 (Ha-34) Ha-36)	6×10^{-5}	0.15
	Er^{169} Er^{171}				9.4 0.31		9.3 0.31			0.60 0.60			
	Er		Kidneys 300 g 7 cm			650			0.02 (Ha-36)		0.02 (Ha-34 Ha-36)	2×10^{-6}	5×10^{-3}
	Er^{169} Er^{171}				9.4 0.31		9.3 0.31			0.02 0.02			
	Er		Liver 1.7×10^3 g 10 cm			433			0.02 (Ha-36)		0.03 (Ha-34) Ha-36)	3×10^{-6}	7.5×10^{-3}
	Er^{169} Er^{171}				9.4 0.31		9.2 0.31			0.02 0.02			
69	Tm		Total body 7×10^4 g 30 cm			675		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Tm^{170}				127		107			1.0 (D)			
	Tm^{171}				694		342			1.0 (D)			
	Tm		Bone 7×10^3 g 5 cm			1000 (Ha-55)			0.95 (Ha-36)		0.65 (Ha-36 Ha-88)	6.5×10^{-5}	0.16
	Tm^{170} Tm^{171}				127 694		113 410			0.69 0.78			
	Tm		Kidneys 300 g 7 cm			335			0.01 (Ha-36)		0.02 (Ha-36 Ha-88)	2×10^{-6}	5×10^{-3}
	Tm^{170} Tm^{171}				127 694		92 226			0.02 0.01			
70	Yb		Total body 7×10^4 g 30 cm			685		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Yb^{175}				4.1		4.1			1.0 (D)			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Yb		Bone 7×10^3 g 5 cm			1000 (Ha-55)			0.85 (Ha-33)		0.58 (Ha-33)	5.8×10^{-5}	0.15
	Yb^{175}				4.1		4.1			0.58			
	Yb		Kidneys 300 g 7 cm			685			0.05 (Ha-33)		0.05 (Ha-33)	5×10^{-6}	0.013
	Yb^{175}				4.1		4.1			0.05			
71	Lu		Total body 7×10^4 g 30 cm			750		$<10^{-4}$ (Ha-36 Ha-55)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Lu^{177}				6.8		6.7			1.0 (D)			
	Lu		Bone 7×10^3 g 5 cm			1000 (Ha-55)			0.9 (Ha-36)		0.68 (Ha-36)	6.8×10^{-5}	0.17
	Lu^{177}				6.8		6.75			0.68			
	Lu		Kidneys 300 g 7 cm			750			0.01 (Ha-36)		0.01 (Ha-36)	10^{-6}	2.5×10^{-3}
	Lu^{177}				6.8		6.7			0.01			
72	Hf		Total body 7×10^4 g 30 cm			563 (Ki-1)		$<10^{-4}$ (compared to Zr)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Hf^{181}				46		43			1.0 (D)			
	Hf		Liver 1.7×10^3 g 10 cm			625			0.5 (Ki-1)		0.45 (Ki-1)	4.5×10^{-5}	0.11
	Hf^{181}				46		43			0.45			

	Hf Hf^{181}		Spleen 150 g 7 cm		46	350	41		0.08 (Ki-1)	0.12	0.13 (Ki-1)	1.3×10^{-5}	0.03
	Hf Hf^{181}		Kidneys 300 g 7 cm		46	563	43		0.02 (Ki-1)	0.02	0.02 (Ki-1)	2×10^{-6}	5×10^{-3}
	Hf Hf^{181}		Bone 7×10^{3} g 5 cm		46	600	43		0.16 (Ki-1)	0.15	0.15 (Ki-1)	1.5×10^{-5}	0.04
73	Ta Ta^{182}		Total body 7×10^{4} g 30 cm		112	240	76	$<10^{-4}$ (Ha-101 compared to Nb)	1.0 (D)	1.0 (D)	1.0 (D)	10^{-4}	0.25
	Ta Ta^{182}		Liver 1.7×10^{3} g 10 cm		112	400 (Ha-38 Ha-87 Ha-88)	88		0.5 (Ha-38 Ha-87)	0.35	0.3 (Ha-38 Ha-87)	3×10^{-5}	0.08
	Ta Ta^{182}		Bone 7×10^{3} g 5 cm		112	300	82		0.25 (Ha-38 Ha-87)	0.22	0.2 (Ha-38 Ha-87)	2×10^{-5}	0.05
	Ta Ta^{182}		Kidneys 300 g 7 cm		112	400	88		0.05 (Ha-38 Ha-87)	0.035	0.03 (Ha-38 Ha-87)	3×10^{-6}	7.5×10^{-3}
	Ta Ta^{182}		Spleen 150 g 7 cm		112	240	76		0.01 (Ha-38 Ha-)87	0.01	0.01 (Ha-38 Ha-87)	10^{-6}	2.5×10^{-3}

* Reference equations unless otherwise indicated.

Gen.* ref.	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
Z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
74	W		Total body 7×10^4 g 30 cm			1 (Ha-34)		0.1 (Ha-34 Ha-101)	1.0 (D)		1.0 (D)	0.1	0.3
	W^{181}				140		1			1.0 (D)			
	W^{185}				74		1			1.0 (D)			
	W^{187}				1		0.5			1.0 (D)			
	W		Bone 7×10^3 g 5 cm			9 (Ha-34)			0.65 (Ha-34 Ha-101		0.07 (Ha-34 Ha-101)	7×10^{-3}	0.02
	W^{181}				140		8.5		Ws-2)	0.60			
	W^{185}				74		8			0.57			
	W^{187}				1		0.9			0.13			
	W		Liver 1.7×10^3 g 10 cm			4 (Ha-34)			0.24 (Ha-34 Ha-101		0.06 (Ha-34 Ha-101)	6×10^{-3}	0.02
	W^{181}				140		3.9		Ws-2)	0.24			
	W^{185}				74		3.8			0.23			
	W^{187}				1		0.8			0.1			
75	Re		Total body 7×10^4 g 30 cm			7 (Ha-89)		0.5 (compared to Tc)	1.0 (D)		1.0 (D)	0.5	0.5
	Re^{183}				73		6.4			1.0 (D)			
	Re^{186}				3.79		2.5			1.0 (D)			
	Re^{187}				1.8×10^{13}		7			1.0 (D)			
	Re^{188}				0.71		0.64			1.0 (D)			

	Re		Thyroid 20 g			3			3×10^{-3} (Ha-89)		7×10^{-3} (Ha-89)	3.5×10^{-3}	3.5×10^{-3}
	Re^{183}		3 cm		73		2.9			3×10^{-3}			
	Re^{186}				3.79		1.7			5×10^{-3}			
	Re^{187}				1.8×10^{13}		3			3×10^{-3}			
	Re^{188}				0.71		0.57			6×10^{-3}			
	Re		Skin 2×10^{3} g			25			0.9 (Ha-89)		0.25 (Ha-89)	0.13	0.13
	Re^{183}		0.1 cm		73		19			0.74			
	Re^{186}				3.79		3.3			0.34			
	Re^{187}				1.8×10^{13}		25			0.89			
	Re^{188}				0.71		0.69			0.27			
	Re		Bone 7×10^{3} g 5 cm			3.5			5×10^{-3} (Ha-89)		0.01 (Ha-89)	5×10^{-3}	5×10^{-3}
	Re^{183}				73		3.3			5×10^{-3}			
	Re^{186}				3.79		1.82			7×10^{-3}			
	Re^{187}				1.8×10^{13}		3.5			5×10^{-3}			
	Re^{188}				0.71		0.59			9×10^{-3}			
	Re		Liver 1.7×10^{3} g 10 cm			14			0.02 (Ha-89)		0.01 (Ha-89)	5×10^{-3}	5×10^{-3}
	Re^{183}				73		11.7			0.02			
	Re^{186}				3.79		2.98			0.01			
	Re^{187}				1.8×10^{13}		14			0.02			
	Re^{188}				0.71		0.68			0.01			
76	Os		Total body 7×10^{4} g 30 cm			2 (Ha-101)		0.1 (Ha-85 Ha-101 com- pared to Pt and Ir)	1.0 (D)		1.0 (D)	0.1	0.3
	Os^{185}				95		2			1.0 (D)			
	Os^{191m}				0.58		0.45			1.0 (D)			
	Os^{191}				16		1.8			1.0 (D)			
	Os^{193}				1.3		0.8			1.0 (D)			

Reference equations unless otherwise indicated.

Gen.* ref. / z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Os		Kidneys 300 g 7 cm			5 (Ha-101)			0.13 (Ha-87)		0.05 (Ha-87) Ha-101)	5×10^{-3}	0.02
	Os^{185}				95		4.8			0.12			
	Os^{191m}				0.58		0.52			0.06			
	Os^{191}				16		3.8			0.11			
	Os^{193}				1.3		1			0.07			
	Os		Liver 1.7×10^{3} g 10 cm			5.5			0.11 (Ha-87)		0.04 (Ha-87 Ha-101)	4×10^{-3}	0.01
	Os^{185}				95		5.2			0.11			
	Os^{191m}				0.58		0.52			0.05			
	Os^{191}				16		4.1			0.09			
	Os^{193}				1.3		1			0.05			
77	Ir		Total body 7×10^{4} g 30 cm			20 (Ha-85)		0.1 (G, compared with Rh)	1.0 (D)		1.0 (D)	0.1	0.3
	Ir^{190}				12		7.5			1.0 (D)			
	Ir^{192}				74.5		15.8			1.0 (D)			
	Ir^{194}				0.79		0.76			1.0 (D)			
	Ir		Kidneys 300 g 7 cm			50			0.11 (Ha-85)		0.045 (Ha-85)	4.5×10^{-3}	0.014
	Ir^{190}				12		9.7			0.06			
	Ir^{192}				74.5		30			0.09			
	Ir^{194}				0.79		0.78			0.05			

	Ir		Spleen 150 g 7 cm			50			0.05 (Ha-85)		0.02 (Ha-85)	2×10^{-3}	6×10^{-3}
	Ir^{190}				12		9.7			0.03			
	Ir^{192}				74.5		30			0.04			
	Ir^{194}				0.79		0.78			0.02			
	Ir		Liver 1.7×10^{3} g 10 cm			27			0.31 (Ha-85)		0.23 (Ha-85)	0.023	0.07
	Ir^{190}				12		8.3			0.25			
	Ir^{192}				74.5		20			0.29			
	Ir^{194}				0.79		0.77			0.23			
78	Pt		Total body 7×10^{4} g 30 cm			24 (Ha-85)		0.1 (Ha-85 compared to Ir)	1.0 (D)		1.0 (D)	0.1	0.3
	Pt^{191}				3		2.7			1.0 (D)			
	Pt^{193m}				3.4		3.0			1.0 (D)			
	Pt^{193}				1.8×10^{5}		24			1.0 (D)			
	Pt^{197m}				0.056		0.056			1.0 (D)			
	Pt^{197}				0.75		0.73			1.0 (D)			
	Pt		Kidneys 300 g 7 cm			60 (Ha-85)			0.25 (Ha-85)		0.1 (Ha-85)	0.01	0.03
	Pt^{191}				3		2.9			0.11			
	Pt^{193m}				3.4		3.2			0.11			
	Pt^{193}				1.8×10^{5}		60			0.25			
	Pt^{197m}				0.056		0.056			0.1			
	Pt^{197}				0.75		0.74			0.1			
	Pt		Spleen 150 g 7 cm			60			0.02 (Ha-85)		8×10^{-3} (Ha-85)	8×10^{-4}	2.4×10^{-3}
	Pt^{191}				3		2.9			8.6×10^{-3}			

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Gen.* ref.	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
Z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Pt^{193m}				3.4		3.2			8.6×10^{-3}			
	Pt^{193}				1.8×10^{5}		60			0.02			
	Pt^{197m}				0.056		0.056			8×10^{-3}			
	Pt^{197}				0.75		0.74			8×10^{-3}			
	Pt		Liver 1.7×10^{3} g 10 cm			20 (Ha-85)			0.12 (Ha-85)		8×10^{-3} (Ha-85)	8×10^{-4}	2.4×10^{-3}
	Pt^{191}				3		2.6			0.14			
	Pt^{193m}				3.4		3.2			0.14			
	Pt^{193}				1.8×10^{5}		20			0.12			
	Pt^{197m}				0.056		0.056			0.14			
	Pt^{197}				0.75		0.72			0.14			
79	Au		Total body 7×10^{4} g 30 cm	$<1.4\times10^{-8}$ (Ti-1 through Ti-7)		120		0.1 (El-1)	1.0 (D)		1.0 (D)	0.1	0.3
	Au^{196}				5.6		5.4			1.0 (D)			
	Au^{198}				2.7		2.6			1.0 (D)			
	Au^{199}				3.15		3.1		–	1.0 (D)			
	Au		Liver 1.7×10^{3} g 10 cm	$<10^{-7}$ (Ti-1 through Ti-7)		300 (El-1 Blo-3)			0.1 (Blo-3)		0.04	4×10^{-3} (El-1)	0.01
	Au^{196}				5.6		5.5			0.04			
	Au^{198}				2.7		2.7			0.04			
	Au^{199}				3.15		3.1			0.04			

	Au		Kidneys 300 g 7 cm	$<10^{-7}$ (Ti-1 through Ti-7)		280			0.07 (Bt-1 Blo-3)		0.03	3×10^{-3}	9×10^{-3}
	Au^{196}				5.6		5.5			0.03			
	Au^{198}				2.7		2.7			0.03			
	Au^{199}				3.15		3.1			0.03			
	Au		Spleen 150 g 7 cm	$<10^{-7}$ (Ti-1 through Ti-7)		240			0.01 (Blo-3)		5×10^{-3}	5×10^{-4}	1.5×10^{-3}
	Au^{196}				5.6		5.5			5×10^{-3}			
	Au^{198}				2.7		2.7			5×10^{-3}			
	Au^{199}				3.15		3.1			5×10^{-3}			
80	Hg	2×10^{-5} (Sl-1)	Total body 7×10^{4} g 30 cm			10 (Ha-85)		0.75 (Sl-1)	1.0 (D)		1.0 (D)	0.75	0.63
	Hg^{197m}				1		0.91			1.0 (D)			
	Hg^{197}				2.7		2.1			1.0 (D)			
	Hg^{203}				45.8		8.2			1.0 (D)			
	Hg		Kidneys 300 g 7 cm	5×10^{-7} (Stk-1)		14.5			0.5 (Ha-85)		0.35 (Ha-85)	0.26	0.22
	Hg^{197m}				1		0.94			0.36			
	Hg^{197}				2.7		2.3			0.38			
	Hg^{203}				45.8		11.0			0.47			
	Hg		Liver 1.7×10^{3} g 10 cm	2.6×10^{-7} (Stk-1)		13.5			0.2 (Ha-85)		0.15 (Ha-85)	0.11	0.09
	Hg^{197m}				1		0.93			0.15			
	Hg^{197}				2.7		2.3			0.16			
	Hg^{203}				45.8		10.4			0.19			
	Hg		Spleen 150 g 7 cm	1.3×10^{-7} (Stk-1)		10 (Ha-85)			0.02 (Ha-85)		0.02 (Ha-85)	0.02	0.01
	Hg^{197m}				1		0.9			0.02			
	Hg^{197}				2.7		2.1			0.02			
	Hg^{203}				45.8		8.2			0.02			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
81	Tl		Total body 7×10^4 g 30 cm	$<8.6\times10^{-8}$ (Ti-1 through Ti-7)		5 (Ha-34)		0.45 (Ha-101)	1.0 (D)		1.0 (D)	0.45	0.48
	Tl^{200}				1.13		0.92			1.0 (D)			
	Tl^{201}				3		1.9			1.0 (D)			
	Tl^{202}				12		3.5			1.0 (D)			
	Tl^{204}				1.1×10^3		5.0			1.0 (D)			
	Tl		Kidneys 300 g 7 cm	$<10^{-7}$ (Ti-1 through Ti-7)		7 (Ha-34)			0.07 (Ha-34 Ha-84)		0.05 (Ha-34 Ha-84)	0.023	0.024
	Tl^{200}				1.13		0.97			0.05			
	Tl^{201}				3		2.1			0.06			
	Tl^{202}				12		4.4			0.06			
	Tl^{204}				1.1×10^3		7			0.07			
	Tl		Lungs 10^3 g 10 cm	8×10^{-8} (Ti-1 through Ti-7)		6 (Ha-34)			7×10^{-3} (Ha-34 Ha-84)		6×10^{-3} (Ha-34 Ha-84)	2.7×10^{-3}	2.9×10^{-3}
	Tl^{200}				1.13		0.95			6×10^{-3}			
	Tl^{201}				3		2.0			6×10^{-3}			
	Tl^{202}				12		4.0			7×10^{-3}			
	Tl^{204}				1.1×10^3		6.0			7×10^{-3}			
	Tl		Muscle 3×10^4 g 30 cm	8×10^{-8} (Ti-1 through Ti-7)		5.5 (Ha-34)			0.6 (Ha-34 Ha-84)		0.54 (Ha-34 Ha-84)	0.24	0.26

	Tl^{200} Tl^{201} Tl^{202} Tl^{204}				1.13 3 12 1.1×10^{3}		0.93 1.9 3.8 5.5			0.55 0.55 0.58 0.59			
	Tl Tl^{200} Tl^{201} Tl^{202} Tl^{204}		Bone 7×10^{3} g 5 cm		 1.13 3 12 1.1×10^{3}	7	 0.97 2.1 4.4 7.0		0.08 (Ha-34 Ha-84)	 0.06 0.06 0.07 0.08	0.055 (Ha-34 Ha-84)	0.025	0.026
	Tl Tl^{200} Tl^{201} Tl^{202} Tl^{204}		Liver 1.7×10^{3} g 10 cm		 1.13 3 12 1.1×10^{3}	5	 0.92 1.9 3.5 5		0.04 (Ha-34)	 0.04 0.04 0.04 0.04	0.04 (Ha-34)	0.02	0.02
82	Pb Pb^{203} Pb^{210} Pb^{212}	4×10^{-4} (Mow-1)	Total body 7×10^{4} g 30 cm	1.1×10^{-6} (Ti-1 through Ti-7)	 2.17 7.1×10^{3} 0.44	1.46×10^{3}	 2.17 1.2×10^{3} 0.44	0.08 (Gd-1)	1.0 (D)	 1.0 (D) 1.0 (D) 1.0 (D)	1.0 (D)	0.08	0.29
	Pb Pb^{203} Pb^{210} Pb^{212}		Bone 7×10^{3} g 5 cm	$<10^{-6}$ (Ti-1 through Ti-7)	 2.17 7.1×10^{3} 0.44	3.65×10^{3} (eq. 48)	 2.17 2.4×10^{3} 0.44		0.7 (Ha-89 Ti-1 through Ti-7)	 0.28 0.56 0.28	0.28 (Ha-89)	0.02	0.08
	Pb		Liver 1.7×10^{3} g 10 cm	2×10^{-6} (Ti-1 through Ti-7)		1947			0.1 (Ha-89 Ti-1 through		0.08 (Ha-89)	6.4×10^{-3}	0.023

* Reference equations unless otherwise indicated.

Gen.* ref. z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Pb^{203}				2.17		2.17		Ti-7)	0.08			
	Pb^{210}				7.1×10^3		1.5×10^3			0.1			
	Pb^{212}				0.44		0.44			0.08			
	Pb		Kidneys 300 g 7 cm	$<1.4\times10^{-7}$ (Ti-1 through Ti-7)		531			0.05 (Ha-89) Ti-1 through Ti-7)		0.14 (Ha-89)	0.01	0.04
	Pb^{203}				2.17		2.16			0.14			
	Pb^{210}				7.1×10^3		494			0.06			
	Pb^{212}				0.44		0.44			0.14			
83	Bi		Total body 7×10^4 g 30 cm	$<4.3\times10^{-9}$ (Ti-1 through Ti-7)		5 (Ha-85 Ha-88)		0.01 (poorly absorbed, G)	1.0 (D)		1.0 (D)	0.01	0.26
	Bi^{206}				6.4		2.8			1.0 (D)			
	Bi^{207}				2.9×10^3		5			1.0 (D)			
	Bi^{210}				5.0		2.5			1.0 (D)			
	Bi^{212}				0.042		0.042			1.0 (D)			
	Bi		Kidneys 300 g 7 cm	$<2\times10^{-8}$ (Ti-1 through Ti-7)		6			0.36 (Ha-85 Ha-88)		0.3 (Ha-85 Ha-88)	3×10^{-3}	0.08
	Bi^{206}				6.4		3.1			0.33			
	Bi^{207}				2.9×10^3		6			0.36			
	Bi^{210}				5.0		3			0.33			
	Bi^{212}				0.042		0.042			0.30			

	Bi		Liver 1.7×10^3 g 10 cm	$<7\times10^{-8}$ (Ti-1 through Ti-7)		15			0.45 (Ha-85 Ha-88)		0.15 (Ha-85 Ha-88)	1.5×10^{-3}	0.04
	Bi^{206}				6.4		4.5			0.24			
	Bi^{207}				2.9×10^3		14.9			0.45			
	Bi^{210}				5.0		3.8			0.22			
	Bi^{212}				0.042		0.042			0.15			
	Bi		Spleen 150 g 7 cm	$<5\times10^{-8}$ (Ti-1 through Ti-7)		10 (Ha-85 Ha-88)			0.02 (Ha-85 Ha-88)		0.01 Ha-85 Ha-88)	10^{-4}	2.6×10^{-3}
	Bi^{206}				6.4		3.9			0.01			
	Bi^{207}				2.9×10^3		10			0.02			
	Bi^{210}				5.0		3			0.01			
	Bi^{212}				0.042		0.042			0.01			
	Bi		Bone 7×10^3 g 5 cm			13.3 (Ha-85 Ha-88)			0.08 (Ha-85 Ha-88)		0.03 (Ha-85 Ha-88)	3×10^{-4}	7.7×10^{-3}
	Bi^{206}				6.4		4.3			0.05			
	Bi^{207}				2.9×10^3		13.2			0.08			
	Bi^{210}				5.0		3.6			0.04			
	Bi^{212}				0.042		0.042			0.03			
84	Po		Total body 7×10^4 g 30 cm			30 (At-9 At-6 Sa-8)		0.06 (At-3 At-9 Sa-8)	1.0 (D)		1.0 (D)	0.06	0.28
	Po^{210}				138.4		25			1.0 (D)			
	Po		Kidneys 300 g 7 cm			70 (At-3 At-9 Hu-4)			0.16 (Fi-2)		0.07 (Fi-2)	4×10^{-3} (At-3)	0.02
	Po^{210}				138.4		46			0.13			
	Po		Spleen 150 g 7 cm			60 (Br-3 Hu-4)			0.08 (Sa-2)		0.04 (Fi-2 Fi-3)	2×10^{-3}	0.01
	Po^{210}				138.4		42			0.07			

* Reference equations unless otherwise indicated.

Gen.* ref. / z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Po		Liver 1.7×10^3 g 10 cm			41			0.23 (Fi-2)		0.17 (Fi-2)	0.01	0.05
	Po^{210}				138.4		32			0.22			
	Po		Bone 7×10^3 g 5 cm			24			0.08 (Fi-2)		0.1	6×10^{-3}	0.03
	Po^{210}				138.4		20			0.08			
85	At		Total body 7×10^4 g 30 cm			27		1.0 (compared to I)	1.0 (D)		1.0 (D)	1.0	0.75
	At^{211}				0.3		0.3			1.0 (D)			
	At		Thyroid 20 g 3 cm			36			0.04 (Ha-46 Ha-88)		0.03 (Ha-46)	0.03	0.023
	At^{211}				0.3		0.3			0.03			
	At		Spleen 150 g 7 cm			27			0.03 (Ha-46 Ha-88)		0.03 (Ha-46)	0.03	0.02
	At^{211}				0.3		0.3			0.03			
	At		Ovaries 8 g 3 cm			13.5			10^{-3} (Ha-46)		2×10^{-3} (Ha-46)	2×10^{-3}	1.5×10^{-3}
	At^{211}				0.3		0.3			2×10^{-3}			
86	Rn		Lungs 10^3 g 10 cm										
	Rn^{220} Rn^{222}				6×10^{-4} 3.83								

87	Fr		Total body 7×10^4 g 30 cm			70		1.0 (compared to Cs)	1.0 (D)		1.0 (D)	1.0	0.75
	Fr		Muscle 3×10^4 g 30 cm			140 (compared to Cs)			0.8 (compared to Cs)		0.4 (compared to Cs)	0.4	0.3
88	Ra	5.5×10^{-12} (Ste-4 Sy-1)	Total body 7×10^4 g 30 cm	1.4×10^{-15} (Hu-1 Kt-3)		8.1×10^3		0.3 (Pit-1)	1.0 (D)		1.0 (D)	0.3	0.4
	Ra^{223}				11.7	12 (Dur-3)	5.9			1.0 (D)			
	Ra^{224}				3.64	6 (Dur-3)	2.3			1.0 (D)			
	Ra^{226}				5.9×10^5	900 (Dur-3)	900			1.0 (D)			
	Ra^{228}				2.4×10^3	250 (Dur-3)	230			1.0 (D)			
	Ra		Bone 7×10^3 g 5 cm	1.7×10^{-14} (Hu-1 Kt-3)		1.64×10^4 (Fi-3 Ea-4)			0.99 (Ge-1)				
	Ra^{223}				11.7		11.7			0.95	0.5	0.15	0.2
	Ra^{224}				3.64		3.64			0.86	0.5	0.15	0.2
	Ra^{226}				5.9×10^5		1.6×10^4			0.99	0.1	0.04	0.03
	Ra^{228}				2.4×10^3		2.1×10^3			0.99	0.1	0.04	0.03
	Ra		Kidneys 300 g 7 cm			10			0.004 (Fi-2)		0.002 (Fi-2)	6×10^{-4}	8×10^{-4}
	Ra^{223}				11.7		5.4			0.002			
	Ra^{224}				3.64		2.7			0.002			
	Ra^{226}				5.9×10^5		10			2×10^{-5}			
	Ra^{228}				2.4×10^3		10			9×10^{-5}			

* Reference equations unless otherwise indicated.

Gen.* ref.	Element and radio-nuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radio-nuclide		By ingestion f_w	By inhalation f_a
Z			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Ra		Liver 1.7×10^3 g 10 cm			10			0.0006 (Fi-2)		0.0004 (Fi-2)	1.2×10^{-4}	1.6×10^{-4}
	Ra^{223}				11.7		5.4			0.0004			
	Ra^{224}				3.64		2.7			0.0005			
	Ra^{226}				5.9×10^5		10			4×10^{-6}			
	Ra^{228}				2.4×10^3		10			2×10^{-5}			
89	Ac		Total body 7×10^4 g 30 cm			2.4×10^4		$<10^{-4}$ (At-13, very poorly absorbed compared to $4f$ rare earths)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Ac^{227}				8×10^3		6×10^3			1.0 (D)			
	Ac^{228}				0.26		0.26			1.0 (D)			
	Ac		Bone 7×10^3 g 5 cm			7.3×10^4 (At-15 compared to Pu)			0.9 (Ha-63)		0.3 (Ha-63)	3×10^{-5}	0.08
	Ac^{227}				8×10^3		7.2×10^3			0.36			
	Ac^{228}				0.26		0.26			0.3			
	Ac		Kidneys 300 g 7 cm			2.4×10^4			0.01 (Ha-32)		0.01 (Ha-32)	10^{-6}	3×10^{-3}
	Ac^{227}				8×10^3		6×10^3			0.01			
	Ac^{228}				0.26		0.26			0.01			

	Ac		Liver 1.7×10^3 g 10 cm			2.4×10^3			0.05 (Ha-63)		0.5 (Ha-63)	5×10^{-5}	0.13
	Ac^{227}				8×10^3		1.9×10^3			0.16			
	Ac^{228}				0.26		0.26			0.5			
90	Th		Total body 7×10^4 g 30 cm			5.7×10^4		$<10^{-4}$ (Ha-8 Dw-2)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Th^{227}				18.4		18.4			1.0 (D)			
	Th^{228}				700		691			1.0 (D)			
	Th^{230}				2.9×10^7		5.7×10^4			1.0 (D)			
	Th^{231}				1.07		1.07			1.0 (D)			
	Th^{232}				5.1×10^{12}		5.7×10^4			1.0 (D)			
	Th^{234}				24.1		24.1			1.0 (D)			
	Th		Bone 7×10^3 g 5 cm			7.3×10^4 (compared to Pu)			0.9 (Ha-8)		0.7 (Ha-8 Ha-29)	7×10^{-5}	0.18
	Th^{227}				18.4		18.4			0.7			
	Th^{228}				700		693			0.7			
	Th^{230}				2.9×10^7		7.3×10^4			0.9			
	Th^{231}				1.07		1.07			0.7			
	Th^{232}				5.1×10^{12}		7.3×10^4			0.9			
	Th^{234}				24.1		24.1			0.7			
	Th		Kidneys 300 g 7 cm			2.2×10^4			0.02 (Ha-8 Ha-29)		0.05 (Ha-8 Ha-29)	5×10^{-6}	0.01
	Th^{227}				18.4		18.4			0.05			
	Th^{228}				700		678			0.05			
	Th^{230}				2.9×10^7		2.2×10^4			0.02			
	Th^{231}				1.07		1.07			0.05			
	Th^{232}				5.1×10^{12}		2.2×10^4			0.02			
	Th^{234}				24.1		24.1			0.05			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Th		Liver 1.7×10^3 g 10 cm			5.7×10^4			0.05 (Ha-8 Ha-29)		0.05 (Ha-8 Ha-29)	5×10^{-6}	0.01
	Th^{227}				18.4		18.4			0.05			
	Th^{228}				700		691			0.05			
	Th^{230}				2.9×10^7		5.7×10^4			0.05			
	Th^{231}				1.07		1.07			0.05			
	Th^{232}				5.1×10^{12}		5.7×10^4			0.05			
	Th^{234}				24.1		24.1			0.05			
91	Pa		Total body 7×10^4 g 30 cm			4.1×10^4		$<10^{-4}$ (Ha-8, compared to $4f$ rare earths)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Pa^{230}				17.7		17.7			1.0 (D)			
	Pa^{231}				1.3×10^7		4.1×10^4			1.0 (D)			
	Pa^{233}				27.4		27.4			1.0 (D)			
	Pa		Bone 7×10^3 g 5 cm			7.3×10^4 (compared to Pu)			0.8 (Ha-8)		0.45 (Ha-8)	4.5×10^{-5}	0.11
	Pa^{230}				17.7		17.7			0.45			
	Pa^{231}				1.3×10^7		7.3×10^4			0.8			
	Pa^{233}				27.4		27.4			0.45			
	Pa		Kidneys 300 g 7 cm			5.1×10^4			0.05 (Ha-8)		0.04 (Ha-8)	4×10^{-6}	0.01
	Pa^{230}				17.7		17.7			0.04			

	Pa^{231}				1.3×10^{7}		5.1×10^{4}			0.05			
	Pa^{232}				27.4		27.4			0.04			
	Pa		Liver 1.7×10^{3} g 10 cm			5.8×10^{4}			0.07 (Ha-8)		0.05 (Ha-8)	5×10^{-6}	0.013
	Pa^{230}				17.7		17.7			0.05			
	Pa^{231}				1.3×10^{7}		5.8×10^{4}			0.07			
	Pa^{233}				27.4		27.4			0.05			
92	U	2×10^{-6} (Da-1)	Total body 7×10^{4} g 30 cm	3×10^{-10}		100 (Ber-1 Ber-3)		$<10^{-4}$ (Ha-1)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	U^{230}				20.8		14.7			1.0 (D)			
	U^{232}				2.7×10^{4}		100			1.0 (D)			
	U^{233}				5.9×10^{7}		100			1.0 (D)			
	U^{234}				9.1×10^{7}		100			1.0 (D)			
	U^{235}				2.6×10^{11}		100			1.0 (D)			
	U^{236}				8.7×10^{9}		100			1.0 (D)			
	U^{238}				1.7×10^{12}		100			1.0 (D)			
	U		Kidneys 300 g 7 cm	2×10^{-8} (Vo-1)		15 (Vo-1 Sx-1 McL-1)			0.065 (Vo-1)		0.11 (Vo-1 Sx-1 McL-1)	1.1×10^{-5}	0.028
	U^{230}				20.8		8.7			0.065			
	U^{232}				2.7×10^{4}		15			0.065			
	U^{233}				5.9×10^{7}		15			0.065			
	U^{234}				9.1×10^{7}		15			0.065			
	U^{235}				2.6×10^{11}		15			0.065			
	U^{236}				8.7×10^{9}		15			0.065			
	U^{238}				1.6×10^{12}		15			0.065 (Vo-1 for all U f_2 values			

[a] Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f'_2	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	U		Bone 7×10^3 g 5 cm	10^{-9} (Ly-1)		300 (Ber-1 Ber-3)			0.85 (Vo-1)		0.33 (Ber-1 Ber-3)	3.3×10^{-5}	0.083
	U^{230}				20.8		19.5			0.44			
	U^{232}				2.7×10^4		300			0.85			
	U^{233}				5.9×10^7		300			0.85			
	U^{234}				9.1×10^7		300			0.85			
	U^{235}				2.6×10^{11}		300			0.85			
	U^{236}				8.7×10^9		300			0.85			
	U^{238}				1.6×10^{12}		300			0.85			
93	Np		Total body 7×10^4 g 30 cm			3.9×10^4		$<10^{-4}$ (Ha-1 Ha-10)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Np^{237}				8×10^8		3.9×10^4			1.0 (D)			
	Np^{239}				2.33		2.33			1.0 (D)			
	Np		Bone 7×10^3 g 5 cm			7.3×10^4 (compared to Pu)			0.85 (Ha-8)		0.45 (Ha-8)	5.4×10^{-5}	0.11
	Np^{237}				8×10^8		7.3×10^4			0.85			
	Np^{239}				2.33		2.33			0.45			
	Np		Kidneys 300 g 7 cm			6.4×10^4			0.05 (Ha-8)		0.03 (Ha-8)	3×10^{-6}	7.5×10^{-3}
	Np^{237}				8×10^8		6.4×10^4			0.05			
	Np^{239}				2.33		2.33			0.03			

	Np		Liver 1.7×10^3 g 10 cm			5.4×10^4			0.07 (Ha-8)		0.05 (Ha-8)	5×10^{-6}	0.013
	Np^{237}				8×10^8		5.4×10^4			0.07			
	Np^{239}				2.33		2.33			0.05			
94	Pu		Total body 7×10^4 g 30 cm			6.5×10^4		3×10^{-5} (Ln-5 Bal-1	1.0 (D)		1.0 (D)	3×10^{-5}	0.25
	Pu^{238}				3.3×10^4		2.2×10^4	Bs-4		1.0 (D)			
	Pu^{239}				8.9×10^6		6.4×10^4			1.0 (D)			
	Pu^{240}				2.4×10^6		6.3×10^4			1.0 (D)			
	Pu^{241}				4.8×10^3		4.5×10^3			1.0 (D)			
	Pu^{242}				1.4×10^8		6.5×10^4			1.0 (D)			
	Pu		Bone 7×10^3 g 5 cm			7.3×10^4 (Ln-5 Ln-12)		Kt-6)	0.9 (Ln-5 Kt-2)		0.8 (Ln-5 Ha-93)	2.4×10^{-5} (Ph-1 Ph-2 Kt-6)	0.2
	Pu^{238}				3.3×10^4		2.3×10^4			0.83			
	Pu^{239}				8.9×10^6		7.2×10^4			0.9			
	Pu^{240}				2.4×10^6		7.1×10^4			0.9			
	Pu^{241}				4.8×10^3		4.5×10^3			0.81			
	Pu^{242}				1.4×10^8		7.3×10^4			0.9			
	Pu		Liver 1.7×10^3 g 10 cm			3×10^4			0.07 (Ln-4 Ha-26)		0.15 (Ln-4 Ha-26)	4.5×10^{-6}	0.038
	Pu^{238}				3.3×10^4		1.6×10^4			0.11			
	Pu^{239}				8.9×10^6		3×10^4			0.07			
	Pu^{240}				2.4×10^6		3×10^4			0.07			
	Pu^{241}				4.8×10^3		4.1×10^3			0.14			
	Pu^{242}				1.4×10^8		3.0×10^4			0.07			
	Pu		Kidneys 300 g 7 cm			3.2×10^4			0.01 (Ln-4 Ha-26)		0.02 (Ln-4 Ha-26)	6×10^{-7}	5×10^{-3}

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
	Pu^{238}				3.3×10^{4}		1.6×10^{4}			0.015			
	Pu^{239}				8.9×10^{6}		3.2×10^{4}			0.01			
	Pu^{240}				2.4×10^{6}		3.2×10^{4}			0.01			
	Pu^{241}				4.8×10^{3}		4.2×10^{3}			0.02			
	Pu^{242}				1.4×10^{8}		3.2×10^{4}			0.01			
95	Am		Total body 7×10^{4} g 30 cm			2×10^{4}		$<10^{-4}$ (Ha-13 Ha-62 compared to $4f$ rare earths)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Am^{241}				1.7×10^{5}		1.8×10^{4}			1.0 (D)			
	Am^{243}				2.9×10^{6}		2×10^{4}			1.0 (D)			
	Am		Bone 7×10^{3} g 5 cm			7.3×10^{4} (compared to Pu)			0.9 (Ha-1 Ha-13)		0.25 (Ha-13)	2.5×10^{-5}	0.063
	Am^{241}				1.7×10^{5}		5.1×10^{4}			0.71			
	Am^{243}				2.9×10^{6}		7.1×10^{4}			0.88			
	Am		Liver 1.7×10^{3} g 10 cm			3.48×10^{3}			0.06 (Ha-13)		0.35 (Ha-13)	3.5×10^{-5}	0.088
	Am^{241}				1.7×10^{5}		3.4×10^{3}			0.07			
	Am^{243}				2.9×10^{6}		3.5×10^{3}			0.06			
	Am		Kidneys 300 g 7 cm			2.7×10^{4}			0.04 (Ha-13)		0.03 (Ha-13)	3×10^{-6}	7.5×10^{-3}
	Am^{241}				1.7×10^{5}		2.3×10^{4}			0.04			
	Am^{243}				2.9×10^{6}		2.7×10^{4}			0.04			

96	Cm		Total body 7×10^4 g 30 cm			2.4×10^4		$<10^{-1}$ (Ha-12 compared to $4f$ rare earths)	1.0 (D)		1.0 (D)	10^{-4}	0.25
	Cm^{242}				162.5		161.4			1.0			
	Cm^{243}				1.3×10^4		8.4×10^3			(D) 1.0			
	Cm^{244}				6.7×10^3		5.2×10^3			(D) 1.0			
	Cm^{245}				7.3×10^6		2.4×10^4			(D) 1.0			
	Cm^{246}				2.4×10^6		2.4×10^4			(D) 1.0			
										(D)			
	Cm		Bone 7×10^3 g 5 cm			7.3×10^4 (compared to Pu)			0.9 (Ha-12)		0.3 (Ha-12)	3×10^{-5}	0.075
	Cm^{242}				162.5		162.1			0.3			
	Cm^{243}				1.3×10^4		1.1×10^4			0.39			
	Cm^{244}				6.7×10^3		6.1×10^3			0.35			
	Cm^{245}				7.3×10^6		7.2×10^4			0.9			
	Cm^{246}				2.4×10^6		7.1×10^4			0.9			
	Cm		Kidneys 300 g 7 cm			2.4×10^4			0.02 (Ha-12)		0.02 (Ha-12)	2×10^{-6}	5×10^{-3}
	Cm^{242}				162.5		161.4			0.02			
	Cm^{243}				1.3×10^4		8.4×10^3			0.02			
	Cm^{244}				6.7×10^3		5.2×10^3			0.02			
	Cm^{245}				7.3×10^6		2.4×10^4			0.02			
	Cm^{246}				2.4×10^6		2.4×10^4			0.02			
	Cm		Liver 1.7×10^3 g 10 cm			3×10^3			0.05 (Ha-12)		0.4 (Ha-12)	4×10^{-5}	0.1
	Cm^{242}				162.5		154.3			0.38			
	Cm^{243}				1.3×10^4		2.5×10^3			0.12			
	Cm^{244}				6.7×10^3		2.1×10^3			0.16			
	Cm^{245}				7.3×10^6		3×10^3			0.05			
	Cm^{246}				2.4×10^6		3×10^3			0.05			

* Reference equations unless otherwise indicated.

Gen.* ref. / Z	Element and radionuclides	Average daily ingestion I (g/day)	Organ of reference, mass (g) effective radius (cm)	Average concentration, C (g/g wet tissues)	Half-life (days)			Fraction from GI tract to blood f_1	Fraction in organ of reference of that in total body f_2		Fraction from blood to organ of reference f_2'	Fraction reaching organ of reference	
					Physical T_r	Biological T_b	Effective T		Element	Radionuclide		By ingestion f_w	By inhalation f_a
			Ch-1			eq. 44, 45	eq. 49			eq.41,42		eq. 47	eq. 46
97	Bk		Total body 7×10^4 g 30 cm			6.5×10^4		3×10^{-4} (compared to Pu)	1.0 (D)		1.0 (D)	3×10^{-5}	0.25
	Bk^{249}				290		289			1.0 (D)			
	Bk		Bone 7×10^3 g 5 cm			7.3×10^4 (compared to Pu)			0.9 (compared to Pu)		0.8 (compared to Pu)	2.4×10^{-5}	0.2
	Bk^{249}				290		289			0.8			
98	Cf		Total body 7×10^4 g 30 cm			6.5×10^4		3×10^{-5} (compared to Pu)	1.0 (D)		1.0 (D)	3×10^{-5}	0.25
	Cf^{249}				1.7×10^5		4.7×10^4			1.0 (D)			
	Cf^{250}				3.7×10^3		3.5×10^3			1.0 (D)			
	Cf^{252}				803		793			1.0 (D)			
	Cf		Bone 7×10^3 g 5 cm			7.3×10^4 (compared to Pu)			0.9 (compared to Pu)		0.8 (compared to Pu)	2.4×10^{-5}	0.2
	Cf^{249}				1.7×10^5		5.1×10^4			0.9			
	Cf^{250}				3.7×10^3		3.5×10^3			0.8			
	Cf^{252}				803		794			0.8			

* Reference equations unless otherwise indicated.

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BIBLIOGRAPHY FOR BIOLOGICAL, MATHEMATICAL AND PHYSICAL DATA*

INTRODUCTION

This bibliography was prepared in conjunction with the "Report of Committee II on Permissible Dose for Internal Radiation—1959 Revision" for the International Commission on Radiological Protection. The bibliography is principally a listing of the reports which were studied in selecting the biological data, and while the list of journals and reference works reviewed is extensive and includes publications of many nations, we do not claim that it is all inclusive. In the Committee II Report, biological data are given for 98 stable elements and about 240 radionuclides. The references used have been coded and indexed by subjects and authors.

Because few experiments have been designed for the purpose of directly determining maximum permissible concentration (MPC) values, many reports had to be consulted to obtain the biological constants used in calculating the MPC's. The MPC values are listed for two general categories—soluble and insoluble compounds; therefore, biological data were reviewed in which various compounds were administered.

In principle, human exposure data provide more reliable values than animal data, but other than data from a few terminal patients, a few accidental exposures and tracer studies using the whole body counter, these data are non-existent. Most estimates of maximum permissible values for human exposure must be based upon animal data. In a few cases different species of animals have been used for the same radionuclide compound, and in these cases the same biological constants were studied and compared.

For convenience the references for the physical and mathematical data have been compiled in an additional listing.

* Compiled by M. J. Cook, Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

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Julius M. Coon
Cr-2
Do-2
Su-1
Su-2
Su-3

A. R. Cooper
Fs-2
Fs-3

John A. D. Cooper
Bul-1
Ky-8

L. F. Cooper
Cp-1

D. Harold Copp
Cd-1
Cd-2
Cd-3
Gr-1
Gr-5
Gr-6
Gr-11
Ha-5
Ha-7
Ha-13
Ha-38
Ha-40
Ha-41
Ha-57
Ha-58
Ha-64
Rs-2

Jerome Cornfield
Br-10
Cor-1

George C. Cotzias
May-1

R. N. Cowden
At-4

R. N. Cowden
At-5
At-8

George R. Cowgill
Hor-1

Dean B. Cowie
Cs-4
Cw-1
Cw-2
Cw-3
Cw-4

R. F. Cowing
Wr-1
Wr-2

Alvin J. Cox, Jr.
Cox-1

Gerald J. Cox
Scw-1

R. A. Craig
Br-14

C. Cramer
Ha-41

Lathan A. Crandall, Jr.
Cra-1

Henry L. Crespi
Br-45

Edgar A. Cress
Ky-6
Ky-7

K. R. Crispell
Pw-1

Charles D. Crowell, Jr.
Ho-12

Josephine Crowley
Ha-8
Ha-9
Ha-23
Ha-27
Ha-37
Ha-38
Ha-53
Ha-84
Ha-85
Ha-86
Ha-88
Ha-89
Ha-91
Ha-92
Ha-93

D. B. Cruickshank
Cu-1

George Cullen
Ar-2

J. N. Cumings
Cg-1
Cg-2

H. J. Curtis
Bl-2
Bl-3

E. M. Cuthbertson
Gr-1
Ha-57

W. F. J. Cuthbertson
Ct-1
Ct-2

Dorice Czajka
Br-45
Br-49
Br-53
Br-54

B. M. Dabyns
Dy-1

Ernest Daigneault
Ky-4

Mary Dailey
Ab-6
Ab-7
Sn-3

Peter P. Dale
Dal-1

R. Duncan Dallam
Mkp-3

S. A. D'Angelo
Dn-1

Esther Peterson Daniel
Di-1
Di-2

A. I. Danilenko
Dan-1

William J. Darby
Hn-2

C. S. d'Argent
Rp-1

N. C. Datta
Dt-1

Pascaline Daudel
Fj-1

H. E. F. Davies
Ey-1

Francis J. Davis
Da-1

G. K. Davis
Co-2
Co-4

G. K. Davis
Co-5
Co-6
Co-10
Co-11
Co-20
Co-22
Co-38
Dv-1
Fe-1
Fe-2
McE-1
Wl-1

R. K. Davis
At-4
At-6
At-7
At-8
At-15

N. K. De
Boy-2
Den-1

Norman Deane
Dr-1
Dr-2

Earl H. Dearborn
Dea-1

C. F. Decker
Br-45
Dec-1

Agatha M. DeLacio
Mb-1

R. J. Della Rosa
Bh-2
Ca-4
Del-1
Del-2
Sa-5
Sa-8
Sm-1

Chester W. DeLong
Dl-1
Dl-2
Kt-4
Ph-5
Ph-6
Th-8

R. H. DeMeio
De-1
De-2

Charles W. Denko
Dek-1

Stanley Derby
Gol-1

S. P. deRubies
Rp-1

L. G. Despain
Stn-5

Gerhard Dessauer
Ho-13

Rhoda Devick
Wr-5

Finn Devik
Br-54

R. Devis
Lac-2

J. J. DeVoldre
Sco-4

Devriendt
Pag-1

Lydia M. DeWitt
Dew-1

L. J. Deysach
Ry-1

A. T. Dick
Dic-1
Dic-2
McE-3

S. L. DiDio
Bg-2
Bg-6

Nicola Di Ferrante
Dd-8

A. DiPasqua
Bek-1
Bek-2

E. DiStefano
DiS-1

Karl Dittmer
Mag-1

Alberta Di Vittorio
Br-36

F. J. Dixon
Wr-3

Theodore Frederic Dixon
Dx-1

C. A. Doan
Sg-1

Ernest L. Dobson
Dob-1

R. Lowery Dobson
Rs-2

N. L. Dockum
Bs-2
Doc-1
Doc-2
Kt-10
Kt-11
Kt-12
Ph-3
Ph-5

Margery Dolan
Kg-1

M. Dongier
Dog-1

I. Doniach
Don-1

Jean H. Dougherty
Bz-1
Stn-5
Stn-8
Stn-9

John Doull
Cr-1
Cr-2
Do-1
Do-2
Do-3
Su-1
Su-2
Su-3

A. L. Dounce
Nu-8

Andrew Dowdy
Dw-1
Dw-2

V. Downing
Ho-5

W. L. Downs
Bh-6
Ho-4
Ho-11

T. G. H. Drake
Tis-1

W. F. Drea
Boi-1

Robert H. Dreisbach
Dre-1

Cecil K. Drinker
Dri-1
Fa-5

Katherine R. Drinker
Fa-5

Douglas R. Drury
Dru-1

Robert Druyan
Hs-3

Reubenia Dubach
Db-1
Db-2
Db-3
Db-4
Db-5

K. P. DuBois
Cr-1
Cr-2
Do-1
Do-2
Do-3
Ky-8
Mx-5
Su-1
Su-2
Su-3

J. Duckworth
Dk-1

Howard Ducoff
Br-5
Br-10
Dc-1

H. C. Dudley
Du-1 through Du-19

R. A. Dudley
Dy-1

B. J. Duffy, Jr.
Hd-2

C. E. Dunlap
Ea-7

Arthur Dunn
Tap-1

Raymond M. Dunn
Ha-21

Gordon M. Dunning
Dun-1

Octavia DuPont
Wr-4

Patricia W. Durbin
Dur-1
Dur-2
Dur-3
Ha-29
Ha-30
Ha-31
Ha-32
Ha-33
Ha-34
Ha-35

Patricia W. Durbin
Ha-36
Ha-43
Ha-44
Ha-48
Ha-49
Ha-63
Ha-74
Ha-75
Ha-76
Ha-77
Ha-80
Ha-82
Ha-97
Ha-98
Ha-101
Ha-102
Ha-103
Ha-104
Ky-8

F. R. Dutron
As-1

E. D. Dyson
Cl-2

Dominic D. Dziewiatkowski
Dd-1
Dd-2
Dd-3
Dd-4
Dd-5
Dd-6
Dd-7
Dd-8
Dd-9
Dd-10

O. D. Easterday
Bv-1

Thomas W. Easton
Et-1

Arthur Ebbert, Jr.
Pw-1

Walter R. Eckelmann
Kp-2
Kp-3

Isidore S. Edelman
Em-1
Em-2
Sd-1

G. M. Edington
Eg-1
Eg-2
Eg-3

YASUYUKI EGASHIRA
Ega-1

WILLIAM G. E. EGGLETON
Ew-1
Ew-2

KARL B. EICHORN
Ha-73

BERNARD EISENBERG
Ai-2

MERRIL EISENBUD
Ei-1
Ei-2
Ei-3
Ei-4
Ei-5

D. M. EKSTEIN
Ls-3

LORENTZ ELDJARN
Ny-1

JAMES S. ELDRIDGE
Tyo-1

ALICE G. ELFTMAN
Ef-1

HERBERT ELFTMAN
Ef-1

JOAN ELIASOPH
Mah-1

LESTER ELLERBROOK
Ge-3

L. E. ELLINWOOD
Sto-2

C. D. ELLIS
Rut-1

M. E. ELLIS
Col-1

C. A. ELVEHJEM
Ej-1
Ej-2
Ej-3
Ej-4
Ej-5
Ne-1

J. O. ELY
El-1

FRITZ EMDE
Jh-1

R. J. EMERSON
Ph-5
Ph-6

E. W. EMERY
Ey-1

ALFRED ENGELS
Mau-1
Mau-2
Mau-3

B. ENGFELDT
En-1
En-2
En-3

J. A. ENGLISH
Du-11

A. ENGSTROM
En-1
En-2
En-4
En-5

C. ENTEMAN
Ha-9
Ha-50

L. A. ERF
La-7
So-5

E. V. ERLEKSOVA
Erl-1

H. E. ESSEX
McK-1

JEAN ETTORI
Mai-1
Mai-2
Mai-3
Mai-4
Mai-5

H. B. EVANS
No-3

R. D. EVANS
Au-4
Ea-1 through Ea-10
Mr-1

J. L. EVERETT
Bee-1

MARK R. EVERETT
Ev-1

W. J. EVERSOLE
Er-1

FLORITA EZMIRLIAN
Md-1
Md-2
Md-4
Md-5
Md-6
Md-7
Md-8
Md-9

FLORITA EZMIRLIAN
Md-10
Md-15
Md-17

G. FAILLA
St-1

LAWRENCE T. FAIRHALL
Au-1
Fa-1
Fa-2
Fa-3
Fa-4
Fa-5
Fa-6

HENRI FAJERMAN
Fj-1

MARLENE FALKENHEIM
Ho-6
Ho-13

WILLIAM G. FARAGHAN
No-5
No-8

HELEN E. A. FARRAN
Sin-1

V. R. FAYTEL'BERG-BLANK
Fay-1

J. P. FEASTER
Fe-1
Fe-2

R. M. FEATHERSTONE
Fea-1
Fea-2

ULRICH FEINE
Scr-2

W. O. FENN
Nt-1

S. D. FENTRESS
Ti-4
Ti-5
Ti-6

IVAN F. FERNEAU
Mc-2

R. FERRETTI
Ni-2

R. FERROUX
Lc-3

CLEMENT A. FINCH
Boh-1
Boh-2
Flu-1
Stv-2

D. Findlay
Fd-1

S. Fine
Fie-1

Donald L. Fink
Hs-3

Robert M. Fink
Fi-1 through Fi-11

Sidney Fink
May-2

Asher J. Finkel
Br-25
Br-45
Br-54
Rs-2

Miriam P. Finkel
Br-4
Br-5
Br-6
Br-7
Br-12
Br-14
Br-15
Br-16
Br-18
Br-20
Br-21
Br-22
Br-28
Br-29
Br-32
Br-33
Br-39
Br-40
Br-41
Br-42
Br-43
Br-44
Br-45
Br-46
Br-49
Br-50
Br-53
Br-54
Fk-1 through Fk-12
Li-2
Li-3
Li-4
Se-3

Raymond D. Finkle
Ab-5
At-10
At-11

Raymond D. Finkle
Fin-1
Fin-2
Fin-3

Camille Finnegan
For-1
Tap-1

Mary I. Fischer
Mw-1
Mw-2
Mw-3
Mw-4
Mw-6

A. M. Fisher
Sct-1

Harvey Fisher
Ha-9
Ha-93
Ja-5

W. Fisher
Mys-2
Stn-5
Stn-8
Stn-9

William R. Fisher
Ln-17

M. Fishler
Ha-9
Ha-50

O. G. Fitzhugh
Fz-1

R. W. Fleming
Nu-8

F. B. Flinn
Fl-1
Fl-2
St-4

J. C. Flood
Cow-1

R. L. Floyd
Stn-5
Vd-2
Vd-4
Vd-5
Vd-6

Rex G. Fluharty
Flu-1
Ve-2
Ve-4

R. J. Flynn
Br-32
Br-45
Br-53

J. M. Foland
Ti-7

William D. Foland
Ti-1
Ti-2
Ti-4
Ti-5
Ti-6
Ti-7

Richard H. Follis, Jr.
Fh-1

Gilbert B. Forbes
Fs-1
Fs-4

R. M. Forbes
Fs-2
Fs-3
Fs-5

Scott Forbush
Cw-4

H. Foreman
For-1
Ha-54
Ha-86
Ha-89
Rs-2

Nadine Foreman
Ha-16

Lyman L. Forker
Ab-1
Ab-2

C. E. Forkner
Sg-1

Robert B. Forney
Fo-1

Richard C. Fowler
Ho-13

W. M. Fowler
Fow-1
Fow-2

F. S. Fowweather
Fw-1

F. W. Fox
Wk-1

G. E. Fradkin
Fra-1

Kurt W. Franke
Mx-3

S. Frant
Ft-1

WILLIAM G. FREDERICK
By-1
McC-1

DONALD S. FREDRICKSON
Fre-1

AUDREY A. FREE
Bra-1
Ct-1

A. STONE FREEDBERG
Zi-1
Zi-2
Zi-3

E. FREERKSON
Frk-1

O. FREUDENBERGER
Stn-8

H. F. FREUNDLICH
Je-1

R. H. FREYBERG
Blo-1
Blo-2
Blo-3

V. FREYDBERG
Fy-1

LARS FRIBERG
Fb-1
Fb-2
Fb-3

ULF FRIBERG
Bos-3

JOAN F. FRIED
Br-28

FELIX FRIEDBERG
Gr-16
Ta-3

HYMER FRIEDELL
Fr-1
Fr-2
Fr-3
Fr-4
Fr-5
Fr-6
Fr-7
Fr-8
Fr-9

B. J. FRIIS-HANSEN
Sd-1

F. M. FROESCHER
Gr-18

R. K. FULLER
Cn-3

J. F. FULTON
Hl-1

H. J. FUNK
Fun-1

JOHN FURCHNER
Ln-22
Sto-1
Sto-2

JACOB FURTH
Fu-1

H. N. FUYAT
Ra-1

E. R. GABRIELI
Ga-1

M. K. GAITONDE
Gt-1

V. N. GALAKHOVA
Vr-1

T. W. GALBRAITH
Bs-8
Ph-5
Ph-6

D. M. GALLAGHER
Au-4

J. C. GALLIMORE
Ber-2
Sx-1

J. A. GAMMEL
Sl-2

H. D. GANGNLY
Bag-1

WILLIAM F. GANONG
Fre-1

SVEN GARDELL
Bos-4

DONALD GARDINER
Br-4

D. E. GARDNER
Bh-2
Bh-6
Brd-2
Ho-16

WARREN M. GARRISON
Ha-38
Ha-46
Ha-60

P. W. GAST
Kp-5

E. O. GASTON
Ja-7

A. A. GATES
Hu-1
Hu-9
Hu-10

R. GAUTIER
Jt-1

MARY LOUISE GAUTSCHI
Tap-1

ELIZABETH GAVETT
Ho-13

FRANCIS GAVIGAN
Bh-2

MARGARET GEE
Ha-29
Ha-32
Ha-33
Ha-34
Ha-35
Ha-36

E. L. GEIGER
Sae-1

DRIEDRICH GENSICKE
Spo-2

LYNN A. GEORGE
Bs-3
Bs-4
Bs-5
Bs-7
Kt-2
Kt-3
Kt-7
Kt-9
Kt-10
Kt-11
Kt-12
Ph-3

ROBERT S. GEORGE
Mb-1

S. N. GERSHOFF
Ger-1

C. F. GESCHICKTER
To-2

A. O. GETTLER
Ge-1
Ge-2
Ge-3

M. E. GETZENDANER
Kt-4

F. R. GIBB
Sco-6

JOHN G. GIBSON, II
Brw-1
Flu-1
Ve-2
Ve-3

I. G. F. GILBERT
Bel-1

ALFRED GILMAN
Gd-1

T. C. GILMOUR
Bg-2
Bg-6

JAMES T. GINN
Ho-13

S. S. GINORI
Gu-1

J. GINSBURG
Gs-1
Ww-2

B. W. GLAD
Mys-2
Stn-8
Stn-9

ROLAND GLASER
Spo-2

BENTLEY GLASS
McE-1
McE-2
McE-3

H. GLAUBERMAN
Gla-1

G. I. GLEASON
Ky-6
Tb-1

B. L. GLENDENING
Gi-1

G. E. GLOCK
Gl-1

JOHN T. GODWIN
She-3

O. E. GOFF
Co-23

R. C. GOLDBERG
Ci-1

RAYMOND W. GOLDBLUM
Gol-1

E. A. G. GOLDIE
Po-2

ARTHUR GOLDMAN
Ls-11

H. C. GOLDTHORPE
Stn-3
Stn-5
Stn-8
Stn-9

LEONARD J. GOLDWATER
Gw-1

HENRY J. GOMBERG
Bj-1

J. K. GONG
Cn-1
Cn-2
Cn-3
Cn-4

LOUIS S. GOODMAN
Gd-1

J. F. GOODWIN
Goo-1

AUBREY GORBMAN
Gm-1

EDGAR S. GORDON
Maa-1

M. A. GORDON
Sb-1

W. H. GORDON
Ov-1

T. GORDONOFF
Mid-1

DONALD M. GOSS
Ws-1

HIROSHI GOTO
Kik-1
Kik-2
Kik-3

R. G. GOULD
Gc-1

THELMA C. GOULD
Gu-1
Gu-2
Gu-3
Gu-4

J. GOVAERTS
Gv-1
Ha-15

EDWIN J. GRACE
Rs-1

E. H. GRAUL
Gra-1

J. GRAY
Pk-2

SEYMOUR J. GRAY
Ml-1

SIEGFRIED FRANZ GREBE
Gb-1

DAVID M. GREENBERG
Ab-1
Ab-2
Gr-1 through Gr-18
Ha-50
Ha-57
Ta-3

JOSEPH GREENBERG
Du-18
Ls-2
Ls-4
Ls-10

JESSE P. GREENSTEIN
Br-51

ROGER L. GREIF
Gre-1

RICHARD C. GREULICH
Leb-2

JAMES S. GREVIOR
Tap-1

ROBERT S. GRIER
Ln-7

GEORGE C. GRIFFITH
Bg-1
Bg-5

D. E. GRODZENSKII
Grd-1
Za-1

JUDA GROEN
Grn-1

E. G. GROSS
Fea-1
Fea-2

WARREN J. GROSS
Go-1
Go-2

E. L. GROVE
Gro-1
Gro-2
Gro-3

T. GRUCCI
Ce-2

W. GRUNDHAUSER
Li-2

PIETRO GUARESCHI
Mor-1

O. Gubeli
Boa-1

C. J. Gubler
Gub-1
Wi-1
Wi-2
Wi-3
Wi-4

W. D. Gude
Ol-1

M. Dean Guelbenzu
San-1

Guestimate
G

G. Guidotti
Gg-1

S. A. Gunn
Gu-1
Gu-2
Gu-3
Gu-4

E. Gunsel
Gun-1

Ralph L. Gunther
Jo-1

Joan Gurian
Br-25
Br-47

Phillip F. Gustafson
Br-6
Br-14
Br-29
Br-39
Br-40
Br-44
Br-49
Br-54
Mn-3
Mn-4
Mn-9
Mn-11
No-7
Ros-1
Ros-2
Rs-2

Paul Gyorgy
Wj-1

Patricia L. Hackett
Bs-8
Hy-4
Hy-5
Hy-8

Patricia L. Hackett
Kt-10
Kt-11
Kt-12
Ph-3
Ph-5

Alexander Haddow
Br-51

Lorraine Haege
Nt-1

Paul F. Hahn
Hn-1 through Hn-7

C. P. Haigh
Hai-1

S. F. Haines
Ke-1

R. Haldin
Mys-3

R. H. Hall
Bh-6
Sco-2

Mary P. Ham
Ham-1
Ham-2
Ham-3

Joseph G. Hamilton
Ha-1 through Ha-104
Ky-8
La-1
La-2
La-6

T. S. Hamilton
Mu-5

Sam L. Hansard
Co-9
Co-11
Co-14
Co-20
Co-27
Fe-1
Fe-2
Kas-1

W. C. Hanson
Kt-3
Kt-12

H. J. Hantke
Mut-2
Mut-3

Michael Hardwick
Ti-7

Edward P. Hardy
Ei-5

Harriet L. Hardy
Ln-16

E. H. Hare
Hai-1

John H. Harley
Ei-3
Ei-4
Ei-5

M. J. Harp
Hp-1

George T. Harrell
Ai-2

R. V. Harrington
Low-1

P. S. Harris
Boe-1
Ln-2
Ln-22

Robert S. Harris
Bro-1
Bro-2
Bro-4
Ea-1
Ea-7

G. E. Harrison
Har-1
Har-2
Har-3
Har-4
Har-5
Har-6

Harold E. Harrison
Hr-1
Hr-2

Helen C. Harrison
Hr-1
Hr-2

Eileen B. Harriss
Sin-1

Gordon C. Harrold
McC-2
McC-3

Benjamin Harrow
Hw-1

E. B. Hart
Ej-1
Ej-2
Ej-3
Ej-5

H. E. Hart
Ls-2
Ls-4
Ls-5

Janet Hartzell
Fr-2

Tsuyoshi Hashimoto
Tak-1

A. Hassen
Hc-1
Hc-2

R. J. Hasterlik
Br-15
Br-18
Br-42
Bri-1
Hs-1
Hs-2
Hs-3
Ja-4
Lb-3

A. Baird Hastings
Hab-1
Gc-1

T. F. Hatch
Ce-2

John B. Hatcher
Bor-2

E. A. Hathaway
Mn-9
Rs-2

Hiroshi Hayani
Hay-1

R. L. Hayes
Co-34

Herman R. Haymond
Ha-90

Jack W. Healy
Hy-1 through Hy-9
Kt-1
Kt-11
Kt-12

J. C. Heath
Hea-1

A. Heffter
Heu-1

D. Mark Hegsted
Dri-1
Stv-2

C. Heidelberger
Ha-19

John W. Hein
Ho-17

W. Heine
Hb-1

Max Heinrich, Jr.
Hei-1

D. A. Heller
Ha-58
Ha-60
Ha-65

Harold L. Helwig
Ash-1

Marilyn Hemenway
Ha-19
Ha-31

Louis H. Hempelmann
Hem-1
Mr-1

C. F. Hendee
Fie-1

Ann Henderson
Ha-77

E. H. Henderson
Bry-1

Franz Hendrych
Heu-1

O. Henn
Hon-1

F. C. Henriques, Jr.
De-1

Kathleen M. Henry
Tom-1
Tom-2

Katherine Henry
Du-5
Du-6
Hen-1

K. E. Herde
Bs-3
Bs-7
Ph-5

J. F. Herrick
Jm-1

S. Hertz
Ea-6
Ea-8

W. Heubner
Heu-1

C. E. Heussner
McC-2

George Hevesy
He-1
He-2
He-3

Elizabeth M. Hewston
Di-2

Francis F. Heyroth
Ck-5

A. Heyrovsky
Hey-1

R. F. Hibbs
Hi-1

George M. Higgins
Jm-1

C. Ruth Hill
Mon-1

Frederick C. Hill
Sac-1

R. Hill
Dk-1
Hil-1

Margaret Hindmarsh
Va-5
Va-6

Yosio Hiramatau
It-1

E. Hirsch
Tie-1

Gertrude Hirsch
Br-4
Br-5
Br-16
Br-18
Br-39
Br-40
Br-44
Se-3
Fk-1
Fk-2

C. R. Hitchcock
Kre-1

Ina Hittle
Fr-2

Yoshio Hiyama
Hiy-1 through Hiy-7

S. O. Hjertquist
En-3

Harold C. Hodge
Ho-1 through Ho-18
Nu-5
Vo-1

E. J. Hodges
Kp-5
Kp-7

R. H. Hodges
Md-2

F. E. Hoecker
Hk-1 through Hk-7

F. W. Hoffbauer
Br-8

M. M. Hoffman
Dog-1

J. Hoffmann
Hf-1 through Hf-9

John R. Hogness
Ro-1

Duncan A. Holaday
Hod-1
Hod-2

W. Holgate
Va-7

J. M. Hollander
Hoa-1

Joanne W. Hollcroft
Br-10
Br-38
Lr-3
Lr-4
Lr-5

H. Hollingshaus
Stn-8

O. L. Hollis
Kt-2
Kt-3
Kt-10
Kt-11
Ph-3
Th-15
Th-17
Th-20
Th-25
Th-27

B. J. Holloway
Br-7
Br-46

A. V. Holmes
Sn-3

R. Holmes
Ey-1

E. F. Holt
Stn-8
Stn-9

P. F. Holt
Hol-1
Hol-2
Hol-3

Dorsey E. Holtkamp
Hil-1

Takenobu Hongo
Tak-1

S. L. Hood
Co-10
Co-12
Ky-8

Reynold L. Hoover
Hv-1

C. A. Hoppert
Dec-1

R. G. Horne
At-8
At-14
Stn-4

V. G. Horstman
Hy-4
Hy-5
Hy-8
Kt-10
Kt-11
Kt-12

M. K. Horwitt
Hor-1

E. Hove
Ej-1
Ej-2

John E. Howard
How-1

R. L. Howard
Sl-2

J. W. Howland
Hd-1
Hd-2

Vladimir Hrstka
Kli-1

D. M. Hubbard
As-1
Ck-2
Ck-3
Ck-8
Kh-3

J. Cramer Hudson
Au-3

Rita Hughes
Sac-1

Robert M. Hughes
Md-5

Bengt Hultqvist
Sie-1

David M. Hume
Fre-1

K. C. Humphreys
Stn-4

R. E. Humphries
Mr-2

F. P. Hungate
Kt-10

Donald Hunter
Ht-3
Ht-5
Ht-6

F. T. Hunter
Ht-1
Ht-2

R. B. Hunter
Ht-4

S. W. Hunter
Kre-1

John B. Hursh
Bh-2
Hu-1 through Hu-17
Hv-1
Lb-7
Lb-10
Nu-5

G. M. Hyde
Bni-5

Arthur B. Hyman
Wit-1

Frances Hyslop
Fa-2

Ryushi Ichikawa
Hiy-2
Hiy-3
Hiy-4

N. Ikariyama
Ok-1

F. I. Ilcewicz
Ros-1
Ros-2
Ros-4

D. I. Ilin
Mos-3

G. W. Imirie
Du-12

Ruth L. Ingalls
In-1

Katashi Inoue
Io-1

Alfred P. Intoccia
Mi-4

J. W. Irvine, Jr.
Ht-1
J. T. Irving
Wk-1
D. Irwin
Kg-4
J. T. Istock
Du-12
Yosoji Ito
It-1
K. Iversen
Ack-1
J. E. Ives
Iv-1
E. B. Jackson
Je-1
Melvin L. Jackson
Jk-1
S. H. Jackson
Tis-1
A. Jacob
Jb-1
Wolfgang Jacobi
Scr-2
Gloria S. Jacobs
Gre-1
Leon Jacobson
Ab-2
Dc-1
Fin-2
Ha-9
Ja-1 through Ja-8
Louis Jacobson
Ha-50
Ha-100
Bertha Jaffe
See-1
Eugene Jahnke
Jh-1
A. H. James
Em-1
Em-2
Joseph M. Janes
Jm-1
Cestmir Jech
Jc-1
W. S. S. Jee
Ac-3
Ac-6
Stn-3
Stn-5
Stn-8
Stn-9
M. R. Jeffrey
Je-1
F. L. Jennings
Br-17
Br-18
Robert B. Jennings
Kra-1
Kra-2
Nylan Jeung
Ha-29
Ha-34
Ha-35
Ha-49
Ha-76
Ha-77
Ha-103
Ha-104
Arnold H. Johnson
Con-1
Helen Johnson
Ha-90
K. Johnson
Ac-6
O. Johnson
For-1
Ln-3
Frances A. Johnston
In-1
J. E. Johnston
Ha-98
Muriel E. Johnston
Ha-29
Ha-35
Ha-48
Ha-49
Ha-63
Ha-74
Ha-75
Ha-76
Ha-77
Ha-80
Ha-82
Ha-103
Ha-104
Ky-8
Perry M. Johnston
Co-30
W. H. Johnston
Ste-1
E. E. Joiner
Bni-5
W. P. Jolley
At-4
W. P. Jolley
At-8
At-14
Norman Jolliffe
Jl-1
D. C. Jones
Cd-2
Cd-3
Ha-41
Hardin B. Jones
Ha-15
Ha 19
Jo-1
Jo-2
Jo-3
La-6
Sn-1
Sn-2
H. G. Jones
Har-6
Jn-1
Leonard Jost
Js-1
Jenifer Jowsey
Jy-1
Jy-2
Jy-3
Jy-4
Jy-5
Jy-6
Ky-8
Ros-1
Ros-4
Rs-2
Tm-3
Tm-4
Tm-5
G. Joyet
Jt-1
J. M. Judd
Eg-1
Eg-2
Eg-3
Berniece Jue
Ha-38
Ha-86
Ha-87
Bernard Kabakow
Ls-13
Martin D. Kamen
Ka-1
S. E. Kaminskaya
Kk-1
Kk-2

KANSAS STATE COLLEGE OF AGRICULTURE AND APPLIED SCIENCE
Kas-1

M. KAPLAN
Ha-50

M. KAPUSCINSKA
Kap-1

W. G. KARAGHAN
Br-18

DAVIS KARNOFSKY
Bc-1

M. M. KASER
Hn-2

L. A. KASHCHENKO
Kal-1

JOSEPH KATZ
Br-46
Kt-1
Kt-3
Kt-4
Kt-5
Kt-6
Kt-8
Kt-9
Ph-1
Ph-5
Ph-6
Th-1
Th-23

B. KAWIN
Ha-7
Hy-4
Hy-5
Hy-8
Kt-10
Kt-11
Kt-12
Kw-1
Kw-2
Kw-3
Rei-1
Rs-2

C. T. KAYLOR
Vc-1
Vc-3
Vc-4
Vc-5

F. R. KEATING, JR.
Ke-1
Ke-2

ROBERT A. KEHOE
Ck-6
Kh-1 through Kh-9

GEOFFREY KEIGHLEY
Bor-1

NANCY KELLER
Stn-2
Stn-3
Stn-4
Stn-5
Stn-7
Stn-8
Stn-9

G. M. KELLERMAN
Kel-1

FRANK J. KELLY
Tr-6

F. E. KELSEY
Hei-1

J. M. KENNEY
Mn-6

N. L. KENT
Kn-1
Kn-2

P. W. KENT
Jy-5

M. E. KERR
Hy-8

P. KEYANONDA
Bz-1

L. L. KHAMAIDE
Kha-1

BARBARA KIDMAN
Tm-2
Tm-6
Tm-7
Tm-8
Tm-9
Tm-11

TAKEHIKO KIKUCHI
Kik-1
Kik-2
Kik-3
Kik-4
Io-1

R. KILPATRICK
Kil-1

CHARLES P. KIMBALL
Fi-3

F. W. KINARD
Kin-1
Kin-2
Kin-3

JOHN F. KINCAID
Sun-1
Sun-2

EARL J. KING
Kg-1 through Kg-5

E. RICHARD KING
Du-10
Ki-1
Pk-1
Pk-2

ETHEL MAY KINNEY
Kv-1

C. A. KINSER
Mu-5

A. F. KIP
Ht-1
Ht-2

BRIAN H. KIRMAN
Lou-1

WALTER KISIELESKI
At-10
Br-5
Br-6
Br-10
Br-15
Br-16
Br-18
Br-36
Fin-1
Fin-2
Fin-3
Fk-2
Li-1
No-1
No-5
No-8
Pa-3
Rs-2

FREDERICK KITTLE
Ki-1

I. KLEEMAN
Ft-1

MAX KLEIBER
Kas-1
Kb-1
Kb-2
Lf-1
Lui-1

ERICH KLEIN
Kle-1

ISRAEL KLEINER
Kl-1

MIROŠ KLIMAK
Kli-1

FLORENCE J. KLIPFEL
Br-45
Br-46

ELIZABETH L. KNAPP
Kna-1

J. P. KNEF
Mr-3

RALPH M. KNISELEY
Ad-1
Ky-5

F. L. KNOWLES
Iv-1

HARVEY C. KNOWLES, JR.
Aj-1

RAY KO
Kor-1

HENRY J. KOCH, JR.
Kc-1
Kc-2

NOBUHIDE KOKUBU
Mat-1

SIMON KOLETSKY
Fr-7
Km-1

JOHN A. KOLMER
Kol-1

R. KOLOGRIVOV
Kp-6

S. K. KON
Hen-1
Tom-1
Tom-2

TSUYSOHI KONO
Kik-1
Kik-2
Kik-3

SAMUEL KORMAN
Ls-11

HARRY A. KORNBERG
Bs-3
Bs-9
Dl-2
Kt-1
Kt-2
Kt-3
Kt-8
Kt-9
Kt-10
Kt-11
Kt-12
Pal-2
Ph-1

HARRY A. KORNBERG
Ph-5
Ph-6
Th-8
Th-14
Th-24
Th-28

GEORGE KOSEL
Ao-1

WILLIAM F. KOSS
Ho-13

A. KOTZAREFF
Ko-1
Ko-2

JANET KOZIOL
Tn-3

LEON KRAINTZ
Kri-1

JACOB S. KRAKUSIN
Kra-1
Kra-2

A. KRAMISH
Krm-1

A. C. KRAUSE
Tu-1

ADOLF KREBS
Kr-1
Kr-2

A. J. KREMEN
Kre-1

JOSEPH P. KRISS
Ks-1

JACK S. KROHMER
Tho-1

HARRY KROLL
Rs-2

LOUIS A. KRUMHOLZ
Ku-1

MASAMI KUGA
Ak-1

U. S. G. KUHN, III
Co-19

F. C. KULHANEK
Ros-1

LAURENCE J. KULP
Kp-1
Kp-2
Kp-3
Kp-4
Kp-5
Kp-6
Kp-7

ROMAN KULWICH
Co-20
Kul-1
Kul-2

ARTHUR S. KUNIN
Dea-1

V. S. KUSHNEVA
Kus-1

HOWARD L. KUSNETZ
Hod-1
Hod-2

JOSEPH F. KUZMA
Aw-2
Aw-3
Kz-1

GRANVIL C. KYKER
Ky-1 through Ky-9

C. W. LABELLE
Bh-6

M. ANTOINE LACASSAGNE
Lc-1 through Lc-7

M. P. LACROIX
Lac-1
Lac-2

SIMON LAJMANOVICH
Lj-1

WILLIAM L. LAMAR
Hv-1

L. F. LAMERTON
Bel-1
Sin-1
Va-6

ISADORE LAMPE
Bj-1

W. B. LANE
Cn-2
Cn-3

C. S. LANFORD
Shr-1

FREDERICK R. LANG
Lan-1

G. LANG
Rei-1

K. LANGE
Ea-3

R. L. LANGE
Stn-9

HEDWIG LANGECKER
Heu-1

LANGERON
Pag-1

WRIGHT H. LANGHAM
An-3
An-4
An-6
An-7
Ln-1 through Ln-22
Ro-1
Sto-2

H. C. LANZ
Ha-8
Ha-11
Ha-27
Ha-37
Ha-47
Ha-53
Ha-91
Lz-1

RALPH E. LAPP
Lp-1
Lp-2

SUZANNE LARCEBEAU
Pao-1

E. J. LARGENT
As-1
Mc-1
Mc-2
Kh-8
Kh-9

FRANK C. LARSON
Maa-1

LARS-GUNNAR LARSSON
Lar-1

H. C. LARUE
Du-1

S. LASKIN
Bh-6

DANIEL LASZLO
Ky-8
Ls-1 through Ls-13
Rs-2

K. A. LATHROP
At-2
At-11
At-12
Br-28

J. SAMUEL LATTES
Lc-1
Lc-2
Lc-4

JEANNE S. LATTES
Lc-5
Lc-6

K. E. LAUTERBACH
Bh-6

J. LAVEDAN
Lc-5

DUANE LA VIOLETTE
Ray-1
Ray-2

BLANCHE J. LAWRENCE
Fin-2
No-2
No-4

JAMES N. P. LAWRENCE
Law-1

JOHN H. LAWRENCE
Bni-1
Bni-5
Jo-3
La-1 through La-7
So-3

JOHN S. LAWRENCE
Fi-7

MARGARET LAWRENZ
Lw-1
Lw-2
Lw-3
Lw-4

ALFRED H. LAWTON
Cw-1 through Cw-3

L. M. LEA
Pon-2

LORNA LEA
Va-4

GLADYS LEAVELL
Dew-1

G. D. LEBEDEVA
Mei-1

C. P. LEBLOND
Leb-1
Leb-2
Fd-1

G. W. LEDDICOTTE
Led-1

VIOLA LEDFELDT
Str-1

C. C. LEE
Jy-4

HELEN C. LEE
Bni-3

J. A. LEE
Go-2

J. M. LEGOFF
Lg-1

H. LEHMAN
Wd-4

ROBERT A. LEHMAN
Spr-1

EDGAR LEIFER
Ro-1

V. K. LEMBERG
Buk-1

F. W. LENGEMANN
Co-24
Co-28
Co-35

E. S. LENHOFF
Kp-7

AARON BUNSEN LERNER
Gol-1

RUTH LERNER
Ha-38

ROMAN LESKO
Br-15
Se-7

J. LESTINA
Br-32
Br-45
Br-49
Br-53
Fk-11

C. LEVADITI
Lv-1

MARTIN B. LEVENE
Ad-1

W. C. LEVIN
Lev-1

M. D. LEVINE
Du-2
Du-4

VICTOR E. LEVINE
Sac-1

L. LEVY
Fea-2

RUTH LEWIN
Ls-2
Ls-3
Ls-4

S. LEWIN
Lei-1

ANNE M. LEWIS
Fs-1

S. J. LEWIS
Le-1

MAURICE V. L'HEUREUX
Lh-1
Lh-2

WILLARD F. LIBBY
Lib-1 through Lib-7

R. I. LIENKI
Ar-2

R. D. LILLIE
Di-1

ARTHUR LINDENBAUM
Ar-5
Br-15

C. W. LINDOW
Pt-2

B. LINDQUIST
Bau-3
Bau-9
Bau-10
Bau-11
Bau-12
Bau-13
Bau-15

B. F. LINDSLEY
Du-6

WILLIARD R. LINE
Ho-12

J. LIQUIER-MILWARD
Hea-1

HERMANN LISCO
Ab-2
Br-5
Br-6
Br-7
Br-10
Br-12
Br-13
Br-14
Br-15
Br-16
Br-20
Br-21
Br-22
Br-28
Br-29
Br-32
Br-35
Br-36
Br-42

HERMANN LISCO
Br-43
Br-45
Fk-9
Ky-8
Li-1
Li-2
Li-3
Li-4

T. A. LITOVITZ
To-2

ALEXANDER A. LITTLE
Lit-1

M. F. LITTLE
Brd-2

N. H. LITVINOV
Lt-1
Lt-2
Lt-3

C. H. LIU
Mcm-1

G. P. LOFGREEN
Lf-1

JAMES E. LOFSTROM
Sik-1

J. H. LOGOTHETOPOULOS
Don-1

E. W. LOHR
Ab-1
Ab-4
Lew-1

L. LOMHOLT
He-2

P. LONTIE
Lon-1

F. LOOMIS
Ha-9

WILLIAM B. LOONEY
Br-15
Br-17
Br-18
Br-44
Hu-15
Ja-4
Lb-1 through Lb-13

J. K. LOOSLI
Vi-1

J. M. LOPEZ DE AZCONA
San-1

EGON LORENZ
Lr-1

EGON LORENZ
Lr-2
Lr-3
Lr-4
Lr-5
Br-10
Br-38

P. C. LORICK
Md-14

R. LOTMAR
Boa-1

C. LOTZ
Bni-2

VIRGINIA LOTZ
Pi-1

W. E. LOTZ
Co-16
Co-26
Co-33

B. J. LOUIE
Ha-65

J. F. LOUTIT
Har-3
Lou-1

S. K. LOVE
Lew-1

W. D. LOVE
Lov-1
Lov-2

F. LOWATER
Gl-1

B. V. A. LOW-BEER
Lo-1
Lo-2

M. LOWE
Stn-5
Stn-8

J. R. LOWRY
Low-1

H. F. LUCAS, JR.
Br-7
Br-14
Br-48
Ros-1
Ros-2
Ros-3
Ste-1
Ste-3
Ste-4

A. J. LUESSENHOP
Ber-2
Sx-1

JACK R. LUICK
Kb-2
Lui-1

F. D. W. LUKERAS
Wj-1

ALF LUND
Ld-1
Ld-2

E. SACERDOTE DE LUSTIG
Mac-1
Mac-2

ROBERT E. LUTZ
Lu-1

HERMANN LUX
Lx-1

WILLIAM C. LYNAM
Fr-2

D. E. LYNCH
Ly-1

G. ROCHE LYNCH
Ly-2

ALFRED R. MAASS
Maa-1

M. MACHEBOEUF
Beg-2
Beg-3

WILLARD MACHLE
Mc-1
Mc-2

G. E. MADDOX
Du-1
Du-7

PEDRO HORACIO MAGNIN
Lj-1

WALTER E. MAGNUSON
Mag-1

M. E. MAHEY
Wi-3

J. P. MAHONEY
Wi-1
Wi-4

LOUIS C. MAILLARD
Mai-1 through Mai-5

E. R. MAIN
Nu-2

M. MAJEROVA
Beo-1

R. I. MAKARYCHEVA
Mav-1

M. C. MALAKAR
Bp-1
Bp-2

CONSTANTINE J. MALETSKOS
Bro-1

R. E. MANCINI
Mac-1
Mac-2
Nz-1
Nz-2

JEANNE F. MANERY
Bw-2

Y. MANIN
Lv-1

MARIAN L. MANLY
Bw-3
Ho-15

W. MANN
Ho-1
Ho-5
Ho-10

W. M. MANNING
Br-11

AMBROGIO MANTEGAZZA
Man-1

A. N. MAREI
Mei-1

A. MARIAKULANDAI
Mak-1

LEONIDAS D. MARINELLI
Mn-1 through Mn-13
Ros-1
Ros-2
Ros-3
Ros-4
Br-14
Br-15
Br-29
Br-39
Br-40
Br-44
Br-49

U. MARINONI
Vt-1

E. K. MARKS
Ja-7
Ja-8

S. MARKS
Bs-2
Bs-3
Bs-5
Bs-7

S. MARKS
Hy-8
Kt-3
Kt-10
Kt-11
Kt-12
Ph-3
Ph-5
Ph-6

H. H. MARRER
Du-19

A. MARSHAK
Mas-1

RICHARD H. MARSHAK
Mah-1

J. H. MARSHALL
Jy-6
Ros-1
Ros-4

E. A. MARTELL
Mar-1
Mar-2

J. B. MARTIN
Bee-1

M. MENCER MARTIN
Mart-1

HARRISON S. MARTLAND, SR.
Mr-1 through Mr-9

PIETRO MASCHERPA
Mp-1

M. W. MASON
Du-10

ALDO MASTURZO
Maz-1

TAKASHI MATSUKI
Kik-3
Kik-4

MARION MATTHEWS
Lr-3

PAUL A. MATTIS
Fr-2
Mt-1
Mt-2

SHINNOSUKE MATUURA
Mat-1

WERNER MAURER
Mau-1
Mau-2
Mau-3

C. A. MAWSON
Mw-1 through Mw-6

S. W. Mayer
Ky-8

E. A. Maynard
Bh-6
Ho-4
Ho-9
Ho-11

Laurence S. Maynard
May-1
May-2

W. V. Mayneord
Mae-1
Mae-2

C. W. Mays
Mys-1
Mys-2
Mys-3
Stn-3
Stn-5
Stn-8
Stn-9
Vd-5

Marcella Mazur
Cr-1
Cr-2
Do-2

Gianfranco Mazzuoli
Ls-12

John Mealey
Mea-1

J. H. Means
Ea-6

Stuart F. Meek
McC-2
McC-3

J. Meissner
Frk-1

Joseph Meites
Me-1

H. Melchinger
Cat-3

H. H. Merritt
Yu-1

I. Meschan
Od-3
Od-4
Od-5

H. B. Messinger
Du-10

Johanna Meyer
Ky-9

R. S. Mical
Stn-3
Stn-5
Stn-8

Joseph Michael
Gr-4
Gr-10

S. Michaelson
Bh-2

S. M. Mikhailovich
Mik-1

V. Milanich
Fr-7

C. E. Miller
Br-15
Br-29
Br-44
Mn-7
Mn-8
Mn-10
Ros-1
Ros-2
Ros-3
Ros-4

E. J. Miller
Sw-1

E. R. Miller
Ha-15
Ha-16
Ha-17
Ha-18
Ha-42
Sn-3

Esther S. Miller
Kt-4

H. Miller
Goo-1

Russell F. Miller
Mil-1

Morris F. Milligan
Hv-1

W. L. Milne
Cn-2
Cn-3
Cn-4

Reginald Milton
Ht-6

W. Minder
Mid-1

Virginia Minnich
Db-1
Db-3

A. S. Minot
Au-1
Min-1 through Min-4

Wallace L. Minto
Fi-6
Fi-9

Avard M. Mitchell
Ml-1

H. H. Mitchell
Fs-2
Fs-3
Fs-5
Lw-1 through Lw-4
Ml-3
Mu-5

H. S. Mitchell
Cp-1

Walter G. Mitchell
Ml-2

Tadashi Miyake
Io-1

Walter Modell
Bod-1

R. H. Mole
Eg-2
Va-7
Va-8

G. W. Monier-Williams
Mow-1

R. A. Monroe
Co-15
Co-23
Co-26

William Montagna
Mon-1

M. L. Montgomery
Sn-1
Sn-2
Sn-4
Sn-5

Joan R. Moor
Bro-2

C. V. Moore
Db-1 through Db-5

Francis D. Moore
Em-1
Em-2
Sd-1

G. E. Moore
Kre-1

J. H. Moore
Moo-1
Moo-2

Elizabeth Moretti
Br-28

W. H. Moretz
Wi-1

A. Morgan
Cl-3
Cl-4
Cl-5
Cl-6
Cl-7
Cl-8

Karl Z. Morgan
Br-3
Br-11
Ha-55
Ha-62
Hu-14
Hy-1
Hy-3
Ma-2
Mkz-1
Mkz-2
Mw-5
Ph-4

D. M. Morken
Bh-2

Donald A. Morken
Mk-1
Mk-2

Elsie Morrell
Wil-1

H. J. Morris
Mo-1

J. P. Morris
St-2

D. C. Morrison
Ha-89

Dempsie B. Morrison
My-1
My-4

P. E. Morrow
Bh-2
Ca-4
Sa-5
Sco-6

Jerome G. Morse
Gu-1

Lura M. Morse
Ta-4

M. E. Morton
Ky-8
Pm-1
Pm-2

Giovanni Moruzzi
Mor-1

Alfredo Moscariello
Ms-1

Campbell Moses
Mb-1

H. Moses
Ros-1

Roscoe S. Mosiman
Ray-1

Yu. I. Moskalev
Mos-1
Mos-2
Mos-3
Mos-4

Harry Most
Cw-4

Nishikawa Motozo
Io-1

C. R. Mott
Stn-3

J. C. Mottram
Re-1

Alvin L. Moxon
Mx-1 through Mx-5

Frank R. Mraz
Pah-1 through Pah-4

Johanna Mueller
Ti-1

Joseph C. Muhler
Muh-1
Muh-2

J. R. Muir
Ber-5

W. C. Mulay
Du-13

Thomas J. Mulhoney
Br-16

James W. Mull
My-2
My-3

R. H. Muller
Ge-2

James W. Mull
My-2
My-3

W. C. Mulry
Pr-1

B. J. Mulryan
Nu-2
Nu-8

J. I. Munn
Du-5
Du-15

D. S. Munro
Kil-1

Makio Murayama
Gr-14

F. J. Murphy
Scw-1

Margaret M. Murray
Bow-1
Bow-2
Gl-1

Hermann Muth
Mut-1 through Mut-5

Roland Muxart
Fj-1

N. B. Myant
Po-1
Po-2

Howard M. Myers
Mye-1
Mye-2

Victor C. Myers
My-1 through My-4

M. Myrick
Br-44

Norman S. MacDonald
Md-1 through Md-17
Rs-2
Wr-5

A. G. MacGregor
Goo-1

William J. MacIntyre
Fr-4
Fr-5

Kenneth MacKenzie
Mz-1 through Mz-3

Florence L. MacLeod
Wil-1

J. C. MacMillan
Wr-3

CLARE MCARTHUR
Md-1
Md-2
Md-5
Md-9

J. T. MCCALL
Fe-1
Fe-2

ROBERT A. MCCANCE
Kn-1
Kn-2
Wd-1 through Wd-7
Wd-9 through Wd-13

PATRICIA T. MCCARTHY
Mh-1

C. M. MCCAY
Mcm-1

WALTER S. MCCLELLAN
Mf-1

L. T. MCCLINTON
Se-4

F. J. MCCLURE
Mu-1 through Mu-5

E. V. MCCOLLUM
Kv-1

WILLIAM MCCONAHEY
Ke-2

KENNETH P. MCCONNELL
Mkp-1
Mkp-2
Mkp-3

CAREY P. MCCORD
McC-1 through McC-3

E. C. MCCRACKEN
McK-1

J. MCCRAE
Mj-1

K. K. MCDANIEL
Ti-2
Ti-4
Ti-5
Ti-6
Ti-7

FRANCIS G. MCDONALD Bil-1

BONNIE B. MCDONALD
Wil-1

WILLIAM D. MCELROY
McE-1 through McE-3

ROBERT MCISSAC
McI-1

JOHN M. MCKIBBIN
Dri-1

WALTER B. MCKIBBEN
Wr-5

A. S. MCLEAN
McL-1

F. C. MCLEAN
Bl-2
Bl-3

REGINA MCLEAN
Au-3

EDWIN MCMILLAN
Bor-1
Bor-2

WILLIAM D. MCNALLY
McN-1

R. R. MCNARY
Kh-3

RUTH MCNUNIS
Br-4

DAVID H. NAIMARK
Nm-1

A. NAKAO
Bd-3
Bd-4
Bd-5
Br-39

KARL FORD NAKKEN
Ny-1

L. E. NAPIER
Boy-1

AGNES NARANJO
Br-24
Br-34
Br-35

D. NARAYANARAO
Vk-1

GEORGE L. NARDI
Na-1 through Na-3

PAUL A. NEAL
Fa-3
Fa-6

WILLIAM NEAL
Br-5
Dc-1

J. B. NEILANDS
Ne-1

A. A. NELSON
Fz-1
Ra-1

ARNE NELSON
En-4

J. EUGENE NELSON
Ve-3

NORTON NELSON
Nn-1

J. T. NERANCY
St-2

A. T. NESS
Cw-1
Cw-2
Cw-3
Cw-4

M. W. NEUMAN
Nu-2
Nu-6

WILLIAM F. NEUMAN
Ao-1
Ho-3
Ho-4
Nu-1 through Nu-10
Sco-3

ROBERT A. NEWBURGER
Mah-1

H. B. NEWCOMBE
Nw-1

R. R. NEWELL
Br-34

R. N. NEWMAN
Ha-31
Ha-32
Ha-33
Ha-34
Ha-35
Ha-36
Ha-49

B. NEYMAN
Tie-1

N. G. NHAVI
Ps-2

W. L. NICHOLSON
Kt-10

J. J. NICKSON
Br-13
Br-36
Br-43
Ni-1
Ni-2
Ni-3

WILLIAM NIEDERMEIER
Bil-1

J. M. NIELSEN
Rie-1

A. Levin Nielson
Nl-1

Annemarie Niklas
Mau-1 through Mau-3

C. Nolan
Sk-2

M. M. Nold
Co-25
Co-32
Co-34
Co-35
Co-36

T. R. Noonan
Al-1
Nt-1

Ake Norhagen
Nh-1

C. Norris
Ge-1

William P. Norris
Br-5
Br-6
Br-7
Br-10
Br-14
Br-15
Br-16
Br-18
Br-32
Br-35
Br-36
Br-44
Br-45
Br-46
Fk-2
Ky-8
Mn-3
No-1 through No-9
Rs-9
Ste-1

W. D. Norwood
Rs-2

P. C. Nowell
Col-1

P. Noyes
Md-14
Wr-5

Constantino Nunez
Nz-1
Nz-2

R. E. Nusbaum
Bg-2

R. E. Nusbaum
Bg-3
Bg-5
Bg-6
Md-1 through Md-3
Md-5 through Md-8
Md-11
Md-12
Md-13
Md-16
Md-17
Wr-5

E. Nussbaum
Hu-13

Oddvar Nygaard
Ny-1

Willa D. Oakley
Bs-4
Kt-2
Kt-7
Kt-9
Kt-10
Kt-11
Ph-3
Th-9
Th-15
Th-20
Th-23
Th-25

James A. O'Brien
Ho-16

M. H. O'Connor
Ah-1

V. J. O'Conor
Bul-1
Ky-8

T. H. Oddie
Od-1 through Od-5

Erik Odeblad
Bos-1
Bos-2
Bos-3
Bos-5
Nh-1

T. T. Odell, Jr.
Ol-1
Up-1

Howard T. Odum
Om-1 through Om-3

Glen E. Ogden
Cw-1
Cw-3

Takawo Ohtsu
Oh-1

H. Okumo
Ok-1

J. O'Leary
Nu-8

R. Oliver
Jy-5
Va-1

R. A. Olsen
Stn-5

J. B. O'Neil
Jy-4

D. F. Opdyke
Op-1

P. A. Orkin
Ht-4

C. R. Orr
Or-1

E. Oshry
Bu-1
Wit-1

T. G. Osler
Ly-2

P. Ottosen
Stn-5

H. Overkamp
Oe-1

W. J. Overman
Ov-1

Roy Overstreet
Ha-5
Ha-9
Ha-50
Ha-100
Ja-2
Ja-5

C. A. Owen
Ke-2

E. C. Owen
Ht-4

Maureen Owen
Jy-1
Tm-4
Tm-5
Va-3
Va-6

J. E. Page
Bra-1

Paget
Pag-1

E. P. Painter
Pa-1 through Pa-3

Etna L. Palmer
Ky-5

R. F. Palmer
Hy-4
Hy-5
Hy-8
Kt-3
Kt-10
Kt-11
Kt-12
Kw-1
Kw-2
Pal-1
Pal-2
Ph-3
Ph-5
Ph-6
Th-24
Th-28

Edward D. Palmes
Nn-1

Claude Paoletti
Pao-1

Charles R. Park
Nn-1

Herbert M. Parker
Kt-8
Ph-1 through Ph-6

D. B. Parrish
Gi-1

Marshall W. Parrott
Ha-29
Ha-30
Ha-31
Ha-32
Ha-33
Ha-35
Ha-43
Ha-44
Ha-49
Ha-63
Ha-75
Ha-77
Ha-97
Ha-98
Ha-104

William Parson
Pw-1

R. J. Parsons
Bni-5

B. D. Pate
Sma-1

J. C. Paterson
Pat-1

M. Patnaik
Pn-1

H. Patrick
Co-23
Pah-1 through Pah-5

V. N. Patwardhan
Ps-1 through Ps-3

P. R. Payne
Cm-1

Wendell C. Peacock
Bc-1
Flu-1

K. Pearson
Pea-1
Pea-2

Nancy S. Pearson
Bro-2

Paul B. Pearson
Kul-1
Kul-2

Charles Pecher
Pe-1
Pe-2

Robert A. Peelor
Bj-1

R. C. Pendleton
Kt-12

Marguerite Perey
Py-1

R. F. Perkins
Hy-4
Hy-5

R. W. Perkins
Rie-1

Jesse D. Perkinson, Jr.
Co-26
Pk-1
Pk-2

Anne Perley
Fs-4

I. Perlman
Pm-1
Pm-2
Hoa-1

Jean Perrin
Lc-1
Lc-2
Lc-4

J. D. Perrings
An-3
An-6

John E. Perry
Lev-1

Kenneth M. A. Perry
Ht-6

F. I. Peterman
Ud-1

W. H. Peterson
Pt-1
Pt-2

I. K. Petrovich
Pet-1

S. S. Phatak
Ps-1

Paul H. Phillips
Mil-1

I. A. Pigalev
Pig-1

J. J. Pinajian
Pah-3

Ernest A. Pinson
An-1
An-2
Ln-11
Pi-1 through Pi-7

H. B. Pinto
Zi-2
Zi-3

A. A. Pinus
Pin-1

A. Pirie
Va-8

G. Pirzio-Biroli
Boh-1
Boh-2

C. B. Pittinger
Fea-1
Fea-2

Robert F. Pitts
Gre-1

W. R. Platt
Pl-1

M. P. Plumlee
Co-9
Co-14
Co-27

E. Eric Pochin
Po-1 through Po-5

W. T. Pommerenke
Hn-7

R. Ponlot
Pon-1
Pon-2

G. D. Popoff
Or-1

James Post
Ha-49
Ha-103

S. Postel
Ab-1
Ab-4

G. D. Potter
Ci-2

R. L. Potter
Mx-5

V. R. Potter
Ej-4

A. M. Potts
Ab-1
Ab-4

Marschelle H. Power
Ke-1
Lit-1

M. L. Premer
Ar-7

T. C. Prentice
Bni-5

L. Previtera
DiS-1

A. P. Prezyma
Pr-1

Robert E. Priest
Dek-1

L. Prodan
Pd-1
Pd-2

C. Ladd Prosser
Pa-1
Pa-3
Pc-1

V. K. Punins'ka
Pu-1

F. B. Queen
Pal-1
Pal-2

M. S. Raben
Rab-1

J. M. Radley
Mae-1
Mae-2

Jack L. Radomski
Ra-1

Paul Raeser
Tr-1

B. Rajewsky
Mut-3
Mut-5
Scr-1

Hugh Ramage
Rm-1
Rm-2

Edward S. Rambousek
Sei-1

Challice Randall
Ho-9

Rulon W. Rawson
Ska-1

C. T. Ray
Tr-2 through Tr-8

George B. Ray
Fa-5

Robert D. Ray
Bau-16
Ray-1 through Ray-3
Rs-2

T. W. Ray
Ry-1

W. H. A. Raymond
Har-1 through Har-5

Barbara Rayner
Tm-1
Tm-3
Tm-6
Tm-7

John Read
Re-1
Re-2

R. F. Recoder
Rc-1

J. W. Redmond
Hi-1

Carl E. Rehfeld
Reh-1
Stn-5
Stn-8
Stn-9

E. C. Reifenstein
Ar-6
Ha-41

K. H. Reiher
Rei-1

George S. Reitter
Mr-7

Arnold S. Relman
Dea-1

H. E. Renschler
Kil-1

Corrine F. Resta
Sik-1

John C. Reynolds
Mn-11

Paul Reznikoff
Au-1

Morris Rhian
Mx-1
Mx-4

R. P. Rhoades
Ab-5

Marion B. Richards
Ri-1

R. K. Richards
Tb-2

Victor Richards
Bir-1

C. R. Richmond
Ln-13
Rh-1

D. Richter
Gt-1

H. G. Rieck
Rie-1
Rie-2

Leola Rietz
Br-9
Br-35

R. W. Rinehart
Cn-4

D. Rittenberg
Sp-1

Johanna Rittner
Ti-7

B. M. Rix
Tp-1

E. S. Robajdek
At-8
At-13

A. Roberts
Ea-6
Ea-8

H. K. Roberts
Db-3

James S. Robertson
Cn-4
Ha-102

J. Robichon
Leb-1

J. Robinson
Sx-1

M. J. Robson
Ja-7
Ja-8

W. T. Rockhold
At-15

Eleanor B. Rodgerson
Cox-1

D. Roesch
At-8
At-14

Betty S. Rogers
Boe-1

Marvin Rollins
Fr-1

R. B. Romney
Lov-1

P. G. Roofe
Hk-1 through Hk-4

R. E. Root
Bh-6
Sco-2

G. Rose
Sf-3

John E. Rose
Br-7
Br-14
Hn-5
Ros-1 through Ros-4

Mary Swartz Rose
Rw-1
Rw-2

R. S. Rosedale
Or-1

D. Rosenbaum
Ja-3

I. N. Rosenberg
Gc-1

S. A. Rosenberg
Fr-3
Fr-7

Irene Rosenfeld
Rf-1
Rf-2

Marcia W. Rosenthal
Br-28
Br-41
Nr-28
Rs-1
Rs-2

Milton S. Ross
Wit-1

J. Rotblat
Rj-1
Rj-2

Dorothy M. Roth
Mkp-3

Lloyd J. Roth
Ro-1

Aser Rothstein
Rt-1

Donald E. Rounds
Md-4
Md-7
Md-8
Md-10
Md-15
Md-17

R. E. Rowland
Br-29
Br-44
Jy-6
Ros-1
Ros-3
Ros-4

J. Rowley
Brd-2

A. C. Roy
Boy-1

G. W. Royster, Jr.
Ber-5

M. I. Rubin
To-2

A. S. Ruby
Stn-9

E. A. Rudik-Gnutova
Za-1

Roberts Rugh
Ru-1 through Ru-3

J. Rundo
Rd-1
Rd-2
Rd-3

L. S. Ruser
Rus-1

David E. Rushing
Hod-2

Edwin R. Russell
Ni-1
Pa-1
Pa-3
Se-7

R. Scott Russell
Co-31
Rl-1

John H. Rust
Ku-1

W. A. Ruth
Lw-1
Lw-3
Ml-3

E. J. Rutherford
Rut-1

O. Rygh
Rg-1
Rg-2

F. R. Sabin
Sg-1

George A. Sacher
Pa-3

Adolph Sachs
Sac-1

Jacob Sacks
Sj-1

V. Sadasivan
Sad-1

U. Saglid
Rd-2

Yoshikazu Sahashi
Sah-1

A. V. St. George
Ge-2

Takeshige Sakurabayashi
Ega-1

P. R. Salerno
Fr-3
Fr-6
Fr-8
Fr-9

Paul R. Salerno
Mt-2

Joseph Samachson
Ls-12
Ls-13

YASUSHI SAMESHIMA
Mat-1

PHYLLIS SANDERS
Sto-1
Sto-2

S. M. SANDERS, JR.
Sae-1

MARGARET H. SANDERSON
Br-46

V. A. SANOTSKII
Sav-1

A. SANTOS-RUIZ
San-1

R. SATO
Br-18

M. M. SAUROV
Mei-1

W. B. SAVCHECK
Ar-1

E. SCHICKS
Lac-2

P. R. SCHLOERB
Sd-1

HERMAN SCHLUNDT
St-1 through St-4

C. L. A. SCHMIDT
Gr-12
Ta-1
Ta-2

G. SCHNEEBELI
Stn-9

FRANCES A. SCHOFIELD
Wil-1

J. C. SCHOOLEY
Co-37

ALFRED SCHRAUB
Mut-1
Mut-2
Scr-1
Scr-2

E. SCHRAUB
Scr-1

NORA E. SCHREIBER
Sl-2
Sl-3

W. G. SCHRENK
Gi-1

HENRY A. SCHROEDER
Sha-1

S. B. SCHRYVER
Sv-1

JACK SCHUBERT
Br-15
Br-25
Br-41
Se-1 through Se-7
Ar-5

ROBERT L. SCHUCH
An-3
An-5
An-6
Ln-17

ARTHUR R. SCHULERT
Kp-2
Kp-3
Kp-7

M. O. SCHULTZE
Sc-1

IRVING L. SCHWARTZ
Sch-1

MELVIN C. SCHWARTZ
Bil-1

E. W. SCHWARTZE
Scw-1

W. SCHWEITZER
Sto-2

NORMAN E. SCOFIELD
Lo-2

C. W. SCOTT
Gro-1
Gro-2

D. A. SCOTT
Sct-1

JAMES K. SCOTT
Sco-1 through Sco-6
Ao-1
Bh-6
Nu-7
Ho-4
To-4

KENNETH G. SCOTT
Ha-8
Ha-9
Ha-12
Ha-13
Ha-23
Ha-27
Ha-28
Ha-37

KENNETH G. SCOTT
Ha-38
Ha-46
Ha-50
Ha-53
Ha-60
Ha-83 through Ha-96
Ha-100
Ha-101
Ja-5
La-4
La-5
So-1 through So-5

ROBERT G. SCOTT
Sa-9

R. K. SCOTT
Od-2

F. I. SCOULAR
Hol-3
Hp-1

G. M. SCRIBNER
Br-32
Br-45
Br-46
Br-50

G. T. SEABORG
Hoa-1

JOHN A. SEALANDER, JR.
Sea-1

J. SEDLET
Hv-1
Rs-2

LINDON SEED
See-1

HENRI C. SEIBERT
Ab-1 through Ab-4

S. M. SEIDLIN
Bu-1

JOSEPH SEIFTER
Sei-1

L. J. SEIGNEUR
Bs-5
Kt-10
Kt-11
Kt-12
Hy-4
Hy-5
Hy-8

HARVEY A. SEIL
Sb-1

A. A. SELDERS
Kt-10

M. Servigne
Lc-7

K. Seymour
Stn-5
Stn-8
Stn-9

Paul D. Shandley
Sy-1

B. Shapiro
Sf-3

Jacob Shapiro
Bh-2
Sf-1
Sf-2

Charlotte P. Shaw
Fa-4

H. C. Shaw
Sl-2

James H. Shaw
Sog-1

Paul A. Shaw
Shw-1

Charles Sheard
McK-1

J. H. Sheldon
Rm-1
Rm-2

G. E. Sheline
Ha-19
Sn-1 through Sn-5

C. J. Shellabarger
She-1 through She-3

H. C. Sherman
Shr-1
Shr-2

J. B. Shields
Ml-3

V. V. Shikhodyrov
Shi-1

Nobuo Shimada
Ak-1

N. F. Shimp
Kc-1

Ray L. Shirley
Sw-1
Sw-2
Wl-1

Alfred T. Shohl
Sh-1

Ephraim Shorr
Sho-1

Rolf M. Sievert
Sie-1
Sie-2

Melvin R. Sikov
Sik-1

Hannah E. Silberstein
Si-1
Fi-7
Fi-10

H. Silverstone
Tn-2
Tn-3

H. C. Simchowitz
Sim-1

Eric L. Simmons
Ab-2

Eric L. Simmons
Ja-1
Ja-6
Ja-8
Fin-2

S. J. Simmons
Sc-1

D. G. Simonsen
Bg-4

Linda Simpson
Sk-2
Sk-5

W. K. Sinclair
Sin-1

F. M. Sinex
Gc-1

Leon Singer
Ar-3
Ar-6
Ar-7
Co-4
Co-6

H. O. Singher
Mn-2

William E. Siri
Bni-5
Sr-1

H. A. Sissons
Jy-2
Va-3

M. L. Sizeland
Sz-1

Bengt N. Skanse
Ska-1
Ska-2

J. T. Skinner
Pt-1

F. H. Skipper
Fe-2

Howard E. Skipper
Co-10
Sk-1 through Sk-5

Ellen Skirmont
Ja-4
Lb-3

Rieta Slakter
Kp-4

R. H. Slater
Ly-2

A. A. Smales
Sma-1

A. H. Smith
Lf-1

Doreen M. Smith
Ham-1 through Ham-3

E. L. Smith
Bra-1

Elmer R. Smith
Ash-1
Kc-1
Kc-2

F. A. Smith
Bh-2
Bh-6
Ca-4
Ho-16
Ho-17
Sa-5
Sa-16
Sm-1

Geneva A. Smith
Sco-5
To-4

G. N. Smith
Kt-3
Ph-5
Ph-6

Homer W. Smith
Dr-1
Dr-2

M. I. Smith
Sm-2 through Sm-4

P. K. Smith
Ra-1

V. H. Smith
Hy-4
Hy-8
Kt-10
Kt-12

J. N. Snider
Bag-1

R. K. Snow
Cn-1

R. H. Snyder
At-1
At-10
At-12
Fin-1 through Fin-3

W. S. Snyder
Sny-1
Sny-2

Reidar F. Sognnaes
Sog-1
Vl-1

M. H. Soley
Ha-25
Ha-45
Ha-67
Ha-68
Ha-73

Torald Sollmann
Sl-1 through Sl-3

K. Solman
Al-1

A. K. Solomon
Gc-1
Sd-1

V. A. Sondak
Son-1

Yu. B. Sosyura
Fay-1

Eleanor M. Sowden
Sti-2
Sti-4

Patricia C. Spain
Md-1
Md-2
Md-4 through Md-10
Md-15
Md-17
Wr-5

Herta Spano
Ln-16

Arnold Sparks
Ao-1
Ho-4

F. G. Spear
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Cadmium (*contd.*)
Ha-101
Ht-3
Kc-1
Kh-9
Pat-1
Pd-1
Pd-2
Pt-1
Rt-1
Sha-1
Sti-1
Sti-3
Sw-1
Ti-1 through Ti-7
Tie-1

Calcium
Ac-2
Ac-3
Ac-5
Ac-6
Ack-2
Ak-1
Alb-1
Amp-1
Ar-2
Ar-3
Ar-6
Ar-7
Au-3
Au-4
Aw-1
Aw-2
Bau-1
Bau-3
Bau-5
Bau-6
Bau-8
Bau-12
Bau-13
Bau-14
Be-1
Bea-1
Bg-3
Bg-5
Bg-6
Bh-2
Bow-2
Br-1
Br-7
Br-10
Br-45
Br-46
Br-50
Br-54

Calcium (*contd.*)
Bri-1
Bro-1
Bro-2
Bro-3
Bro-4
Cat-1
Cd-1
Co-7 through Co-11
Co-13 through Co-18
Co-24
Co-25
Co-27
Co-28
Co-29
Co-31
Co-32
Co-33
Co-35
Co-36
Co-37
Co-38
Co-39
Co-40
Co-41
Cs-1
Dre-1
Dur-3
Dy-1
Ea-10
En-3
Fh-1
Fk-4
Fk-6
Fs-3
Fy-1
Gol-1
Gr-2
Gr-8
Gr-12
Gr-13
Gr-15
Gr-18
Ha-16
Ha-34
Ha-38
Ha-66
Ha-83
Ha-87
Har-4
Hay-1
He-1
Hen-1
Hiy-6
Ho-6

Calcium (*contd.*)
How-1
Hr-1
Hr-2
Hy-5
It-1
Kas-1
Kb-2
Kc-1
Kik-3
Kna-1
Kor-1
Kp-3
Kt-10
Kt-11
Kt-12
Kz-1
La-2
Lac-1
Lew-1
Lh-1
Lh-2
Lon-1
Ls-1
Ls-5
Ls-6
Ls-7
Ls-8
Ls-10
Ls-12
Ls-13
Ls-14
Lui-1
Mcm-1
Md-11
Md-12
Md-13
Md-14
Md-16
Mid-1
Mn-5
Moo-1
Moo-2
Mye-1
No-1
No-2
No-4
No-6
No-9
Nu-9
Pe-1
Pe-2
Pon-1
Pon-2
Ps-3

Calcium (*contd.*)
Rc-1
Rm-1
Ros-1
Ros-4
Rs-2
San-1
Se-2
Sho-1
Sta-1
Sun-3
Sw-2
Sz-1
Th-24
Th-28
Ti-2 through Ti-7
To-2
Tom-1
Tom-2
Up-1
Ut-1
Ut-2
Ut-3
Vc-5
Vi-1
Wan-1
Wd-1
Wd-2
Wd-4
Wd-7
Wd-8
Wd-9
Wil-1
Wk-1
Wl-1
Wr-5
Ya-1

Carbon
Al-1
Ar-4
Ar-5
Bau-9
Bd-1
Bd-2
Bd-3
Bd-4
Bd-5
Bh-4
Bl-1
Bl-2
Bl-3
Bl-4
Bni-1
Bni-2
Bni-3

Carbon (*contd.*)
Bni-4
Bo-1
Bow-2
Br-1
Br-2
Br-5
Br-17
Br-18
Br-23
Br-24
Br-26
Br-30
Br-34
Br-35
Br-36
Br-37
Br-39
Co-10
Dk-1
Dru-1
Ev-1
Fh-1
Fu-1
Gc-1
Gr-16
Gr-17
Gv-1
He-1
Kb-1
La-1
La-2
Leb-2
Na-1
Na-2
Na-3
Ro-1
Se-1
Se-2
Sf-3
Sk-1
Sk-2
Sk-3
Sk-4
Sk-5
Spi-2
Sr-1
Ss-1
Ss-2
Ss-3
Tb-1
Tol-1
Vu-1

Cerium
Ab-3

Cerium (*contd.*)
Ab-4
At-2
Bl-1
Br-12
Br-20
Br-21
Br-54
Cr-1
Dk-1
Dur-3
Fra-1
Ha-1
Ha-4
Ha-5
Ha-7
Ha-9
Ha-10
Ha-14
Ha-19
Ha-22
Ha-26
Ha-31
Ha-36
Ha-40
Ha-51
Ha-76
Ha-77
Ha-79
Ha-83
Ha-86
Hd-1
Jy-6
Kha-1
Ky-7
Ky-8
Li-3
Ln-12
Ln-19
Lx-1
Mos-1
Mos-2
Mos-4
Ros-1
Se-2

Cesium
An-8
Bal-2
Boo-1
Br-29
Br-54
Cl-4
Co-7
Co-12
Co-42

Cesium (*contd.*)
Cr-1
Ew-2
Ha-1
Ha-4
Ha-9
Ha-10
Ha-26
Hiy-5
Hy-4
Hy-5
Kha-1
Kt-2
Kt-10
Kt-12
Ky-8
Led-1
Ln-13
Ln-17
Ln-18
Ln-19
Ln-21
Lov-2
Mn-7
Mn-8
Mn-10
Mos-3
Pah-1
Pah-2
Pah-4
Pah-5
Rd-3
Rh-1
Ros-1
Ros-2
Ros-3
Ros-4
Spi-4
Stn-8
Th-18
Th-21
Tr-2
Ut-1 through Ut-3

Chlorine
Alb-1
Bn-12
Bod-1
Bow-2
Clo-1
Co-38
Dr-2
Ev-1
Fs-1
Ha-70
Hab-1

Chlorine (*contd.*)
Hw-1
Sh-1
Sun-3
Tr-4
Tr-5
Tr-8
Ut-1
Vu-1
Wc-1
Wc-2

Chromium
Co-13
Co-17
Co-18
Co-19
Con-1
Ga-1
Ha-83
Kc-1
Kh-8
Kh-9
Kor-1
Kri-1
Ml-1
Rt-1
Sha-1
Sti-1
Sti-3
Sz-1
Ti-1 through Ti-7
Tie-1
Uo-1

Cobalt
Be-1
Beg-1
Beg-2
Beg-3
Bra-1
Co-1
Co-2
Co-5
Co-10
Co-22
Co-23
Co-38
Ct-1
Ct-2
DiS-1
Ev-1
Ew-2
Fs-2
Gr-1
Gr-11
He-1

Cobalt (*contd.*)
Heu-1
Hey-1
Hp-1
Jb-1
Kas-1
Kc-1
Kh-8
Kh-9
Kn-2
Kor-1
La-3
Led-1
Lg-1
Ma-2
Mp-2
Rt-1
San-1
Sha-1
Sti-1
Sti-3
Ti-1 through Ti-7
Un-1
Vt-1

Copper
Alb-1
Ash-1
Be-1
Bee-1
Bg-1
Bg-2
Bg-3
Bg-5
Bg-6
Brd-1
Brg-1
Bru-1
Cg-2
Ck-4
Ck-5
Ck 7
Co-3
Co-6
Co 10
Co-20
Co-38
Ct-2
Dew-1
Dic-2
Ej-4
Ev-1
Ew-2
Gol-1
He-1
Hol-3

Copper (*contd.*)
Hw-1
Jb-1
Kas-1
Kc-1
Kc-2
Kh-4
Kh-7
Kh-8
Kh-9
Kl-1
Koe-1
Kor-1
Led-1
McE-1
McE-3
Nl-1
Pt-2
Rc-1
Rm-1
Rm-2
Rt-1
Rw-1
Sac-1
Sah-1
San-1
Sc-1
Sha-1
Sti-1
Sti-3
Sun-3
Sz-1
Ti-1 through Ti-7
Ts-3
Tu-1
Un-1
Vn-1
Wd-7
Wi-1
Wi-2
Wi-3
Wi-4

Curium
Dk-1
Dur-3
Ha-1
Ha-12
Ha-19
Ha-26
Ha-94
Se-2

Dysprosium
Ha-33
Ha-36
Lx-1

Erbium
Ha-34
Ha-36
Ky-7
Europium
Dur-3
Ha-15
Ha-17
Ha-18
Ha-29
Ha-33
Ha-36
Ky-8
Vc-2
Fluorine
Alb-1
Ar-1
Bh-2
Bh-4
Bh-6
Boi-1
Bow-1
Bow-2
Brd-2
Bw-2
Cd-1
Co-13
Co-26
Co-33
Ew-2
Ge-3
Gl-1
Ham-1
Ham-2
Ham-3
Ho-16
Ho-17
Hv-1
Kh-8
Kh-9
Lw-1
Lw-2
Lw-3
Lw-4
Mak-1
Mat-1
Mc-1
Mc-2
Mh-1
Mil-1
Mu-1
Mu-2
Mu-3
Mu-4
Mu-5

Fluorine (*contd.*)
Muh-1
Muh-2
Pah-3
Rc-1
Sun-3
Tis-1
Un-1
Vk-1
Vl-1
Wa-1
Wa-2
Wh-1
Francium
Py-1
Gadolinium
Ha-34
Ha-36
Ky-7
Lx-1
Gallium
Bm-1
Bm-2
Du-1 through Du-7
Du-10
Du-11
Du-12
Du-13
Du-15
Du-19
Ha-20
Kc-1
Lan-1
Pk-1
Pk-2
Ti-1 through Ti-7
Germanium
Du-8
Du-9
Ha-21
Rt-1
Gold
Blo-1
Blo-2
Blo-3
Bt-1
Dew-1
Ef-1
El-1
Ew-2
Fr-3
Fr-6
Fr-8
Fr-9
Fu-1

Gold (*contd.*)
Gra-1
Ha-84
Kn-1
Rt-1
Tb-1
Ti-1 through Ti-7
Hafnium
Ki-1
Helium
Beh-1
Beh-2
Beh-3
Holmium
Ha-33
Ha-36
Ha-86
Ky-7
Spo-2
Hydrogen (**deuterium**)
Bo-1
Br-45
Br-46
Em-1
Em-2
Kt-3
Ph-6
Sd-1
Hydrogen (**tritium**)
An-1
An-2
An-4
An-7
Bni-5
Br-9
Br-17
Br-18
Cm-1
Dl-1
Dl-2
Hv-1
Kt-3
Law-1
Ln-8
Ln-11
Ln-19
Ln-20
Ph-2
Ph-4
Ph-5
Ph-6
Pi-1 through Pi-7
Se-2
Sog-1
Th-2 through Th-8

Hydrogen (tritium) *(contd.)*
Th-10 through Th-14
Th-19
Th-22
Vu-1

Indium
Ha-19
Ha-101
McC-2
McC-3
Rt-1
Sco-5
Sco-6
To-4
Tur-1

Iodine
Ab-7
Ack-1
Ad-1
Alb-1
Bh-2
Bj-1
Brw-1
Bs-1
Bs-2
Bs-3
Bs-5
Bs-7
Bs-8
Cha-1
Ci-1
Ci-2
Cl-1
Cn-4
Co-10
Co-13
Co-17
Co-18
Co-38
Dn-1
Dog-1
Don-1
Dun-1
Dur-1
Dur-2
Ea-6
Ea-8
Fd-1
Fr-4
Fr-5
Fre-1
Fu-1
Gm-1
Gra-1
Ha-1

Iodine *(contd.)*
Ha-4
Ha-16
Ha-17
Ha-18
Ha-25
Ha-26
Ha-28
Ha-29
Ha-31
Ha-32
Ha-33
Ha-35
Ha-45
Ha-49
Ha-51
Ha-59
Ha-66
Ha-67
Ha-68
Ha-70
Ha-73
Ha-74
Ha-78
Ha-79
Ha-82
Ha-98
Ha-102
Hai-1
Har-3
Hd-1
Hd-2
Ho-1
Ho-5
Ho-10
Hy-4
Hy-5
Jo-1
Jo-2
Jt-1
Kal-1
Kas-1
Ke-1
Kh-8
Kh-9
Kle-1
Kli-1
Ks-1
Kt-3
Kt-10
Kt-11
Kt-12
La-1
La-2
Lor-1

Iodine *(contd.)*
Lz-1
Mb-1
Mc-1
Mi-2
Mi-3
Mi-4
Mi-5
Mi-6
Mn-5
Mz-1
Nn-1
Od-1
Od-2
Od-3
Od-4
Od-5
Ph-2
Ph-5
Ph-6
Pm-2
Pn-1
Po-1
Po-2
Po-3
Po-4
Pu-1
Rab-1
Ru-1
Ru-2
Ru-3
See-1
Sin-1
Ska-1
Ska-2
Sn-3
Sog-1
Sun-3
Tb-1
Ty-1
Un-1
Ut-1
Ut-3
Wc-2

Iridium
Ha-85
Ha-89
Ha-101

Iron
Ac-1
Alb-1
Bad-1
Bee-1
Bel-1
Bg-1

Iron (*contd.*)
Bg-2
Bg-3
Bg-5
Bg-6
Boh-1
Boh-2
Bp-1
Bru-1
Cg-2
Co-10
Co-38
Db-1
Db-2
Db-3
Db-4
Db-5
Flu-1
Fow-1
Fow-2
Gol-1
Gr-1
Gr-5
Gr-6
Gr-9
Grn-1
Gub-1
Ha-29
Ha-66
Heu-1
Hn-1 through Hn-7
Hol-3
Ht-5
In-1
Je-1
Jl-1
Kas-1
Kc-1
Kh-8
Kh-9
Kor-1
La-1
La-2
Lit-1
Oe-1
Rc-1
Rm-1
Sac-1
San-1
Stv-2
Sun-3
Sz-1
Ti-1 through Ti-7
Tie-1
Ts-3

Iron (*contd.*)
Tu-1
Un-1
Wd-6 through Wd-13
Wk-1

Krypton
La-6

Lanthanum
At-10
At-12
Bl-1
Cn-2
Cr-1
Cr-2
Do-2
Fi-15
Fin-3
Ha-1
Ha-4
Ha-9
Ha-10
Ha-16
Ha-26
Ha-34
Ha-36
Ha-51
Ha-86
Hd-1
Ky-7
Ky-8
Ls-3
Ls-4
Ls-7
Ut-1

Lead
Alb-1
Au-1
Au-2
Au-3
Bag-1
Bg-1
Bg-2
Bg-3
Bg-4
Bg-5
Bg-6
Brg-1
Ck-4
Ck-7
Ev-1
Fa-3
Fa-4
Gol-1
Ha-89
Ha-101

Lead (*contd.*)
Hor-1
Ht-4
Kc-1
Kh-1 through Kh-9
Kor-1
Ly-2
Md-8
Md-9
Min-1
Min-2
Min-3
Min-4
Ml-3
Rc-1
Rm-2
San-1
Sha-1
Sl-1
Sti-1
Sti-3
Sun-3
Sz-1
Ti-1 through Ti-7
Tie-1
Ts-1
Ts-2

Lithium
Ew-2
Kn-1
Md-3
Md-6
Ra-1
Rc-1
Rm-2
San-1
Sz-1
Ti-4
Ti-5
Ti-6

Lutetium
Ha-29
Ha-36
Ha-86
Ky-2
Ky-3
Ky-8
Ky-9

Magnesium
Alb-1
Bee-1
Bow-2
Bp-2
Gol-1
Gr-12

Magnesium (*contd.*)
Gr-15
Hi-1
Kc-1
Kor-1
Lew-1
Mag-1
Rc-1
Rm-1
Rt-1
San-1
Sun-3
Sz-1
Ti-1 through Ti-7
Wd-1
Wd-2
Wd-4
Wd-7
Wk-1

Manganese
Alb-1
Bee-1
Bg-1
Bg-2
Bg-3
Bg-5
Bg-6
Bn-1 through Bn-9
Bn-11
Bn-12
Bn-13
Bn-14
Bp-1
Br-28
Brg-1
Bru-1
Ck-4
Co-1
Co-38
Ct-2
Ej-1
Ej-3
Ew-2
Fa-6
Gol-1
Gr-1
Gr-3
Gr-8
Ha-50
Ha-83
Ha-88
Hb-1
Heu-1
Hil-1
Kas-1

Manganese (*contd.*)
Kh-4
Kh-7
Kh-8
Kh-9
Kn-2
Kor-1
Led-1
May-1
May-2
Mj-1
Rc-1
Ri-1
Rm-2
Rt-1
Rw-1
Ry-1
San-1
Sha-1
Sti-1
Sti-3
Sun-3
Sz-1
Tf-1
Ti-1 through Ti-7
Tie-1
Tu-1
Un-1
Ut-2

Mercury
Ai-1
As-1
Bg-1
Bg-4
Fb-3
Fs-2
Gre-1
Ha-85
Ha-101
Ht-6
Hv-1
Kh-9
Ov-1
Sl-2
Sl-3
Stk-1
Stk-2
Tr-6
Yu-1

Molybdenum
Bee-1
Bg-2
Bg-3
Bg-5
Bg-6

Molybdenum (*contd.*)
Bn-2
Bn-6
Bn-7
Bn-8
Bn-9
Bn-10
Bn-13
Co-3
Co-4
Co-10
Co-20
Co-38
Dic-1
Dv-1
Ej-5
Ev-1
Ha-50
Ha-88
Ha-89
Ha-101
Kas-1
Kc-1
Kh-9
McE-1
McE-3
Mx-3
Ne-1
San-1
Sha-1
Sti-1
Sti-3
Sw-2
Ti-1 through Ti-7
Tie-1
Un-1
Ut-2

Neodymium
Ha-20
Ha-36
Ky-7
Lx-1

Neptunium
Ha-1
Ha-4
Ha-8
Ha-15
Ha-26
Ha-27
Ha-50
Ha-88
Ja-5

Nickel
Beg-1
Beg-2

Nickel (*contd.*)
Brg-1
Co-17
Co-18
Ew-2
Fa-5
Heu-1
Kc-1
Kh-9
Kn-2
Kor-1
Mp-1
Ps-1
Rt-1
San-1
Sha-1
Sti-1
Sti-3
Sun-1
Sun-2
Sun-4
Ti-1 through Ti-7
Tie-1
Un-1
Ws-1

Niobium
Bl-1
Cr-1
Cr-2
Do-1
Do-2
Do-3
Ha-1
Ha-4
Ha-17
Ha-20
Ha-22
Ha-26
Ha-51
Ha-101
Ky-8
Su-2
Ut-1

Nitrogen
Alb-1
Beh-2
Beh-3
Bow-2
Fs-3
La-1
McE-3
Pw-1
Sp-1
Sun-3
Tb-1

Nitrogen (*contd.*)
Wd-7
We-1

Osmium
Bur-1
Ha-87
Ha-101
Ht-3
Rt-1

Oxygen
Alb-1
Bni-1
Bni-4
Br-17

Palladium
Ha-89
Ha-101

Phosphorus
Ack-2
Amp-1
At-1
Bau-2
Bau-5
Bau-6
Bau-10
Bau-11
Bau-15
Bea-1
Bea-5
Bl-1
Bon-1
Bow-2
Br-1
Br-18
Br-33
Br-36
Bw-2
Bw-3
Cd-1
Co-10
Co-13
Co-16
Co-17
Co-38
Co-39
Dv-1
El-1
En-3
Fay-1
Fh-1
Fk-3
Fk-4
Fr-1
Fr-2
Fr-3

Phosphorus (*contd.*)
Fr-6
Fr-7
Fr-8
Fr-9
Frk-1
Fs-3
Fu-1
Ga-1
Gd-1
Gol-1
Gr-7
Gr-12
Gr-15
Grd-1
Ha-16
Ha-22
Ha-41
Ha-66
Hd-1
He-3
Hem-1
Ho-15
Ho-18
How-1
Hy-4
Hy-5
Hy-9
Io-1
Jo-3
Jy-4
Kas-1
Kb-1
Kb-2
Km-1
Kt-11
Kt-12
Kw-1
Kw-2
Kw-3
La-1
La-2
La-4
La-5
La-7
Lac-2
Leb-1
Lf-1
Lo-1
Lo-2
Mas-1
Mb-1
McE-1
McE-2
Mcm-1

Phosphorus (*contd.*)
Mn-5
Mn-6
Moo-1
Moo-2
Mye-2
Ph-4
Pl-1
Ps-2
Ps-3
Rei-1
Rs-2
San-1
Sea-1
Sik-1
So-2
So-3
So-4
So-5
Sog-1
Son-1
Sun-3
Sz-1
Tak-1
Tap-1
Tb-1
The-1
Ti-2
Ti-3
Ti-4
Ti-5
Ti-6
Ti-7
Ut-1
Ut-2
Wd-7
Wd-8
Wd-9
Wk-1
Wr-1
Wr-2
Wr-3
Wy-1
Wya-1
Yb-1
Za-1

Platinium
Ha-85
Ha-101
Rt-1

Plutonium
Ab-1
Ab-2
Ab-5
Bai-1

Plutonium (*contd.*)
Bal-1
Bh-3
Bl-1
Bl-5
Br-1
Br-4
Br-5
Br-8
Br-12
Br-15
Br-17
Br-20
Br-21
Br-27
Br-33
Br-40
Br-41
Br-42
Br-43
Br-44
Br-54
Bs-4
Buk-1
Bz-1
Cat-1
Doc-1
Doc-2
Dur-3
Fi-2
Fi-5
Fi-8
Fin-2
Fk-4
Fk-6
Fk-7
Fk-10
For-1
Fra-1
Fu-1
Ha-1
Ha-5
Ha-19
Ha-26
Ha-37
Ha-38
Ha-64
Ha-66
Ha-83
Ha-85
Ha-92
Hd-1
Hiy-5
Hy-4
Hy-5

Plutonium (*contd.*)
Hy-7
Ja-6
Kt-1 through Kt-12
La-2
Li-1
Li-4
Ln-1 through Ln-8
Ln-10
Ln-12
Ln-16
Ln-19
Ln-23
Mi-1
Ni-1
Pa-1
Pa-3
Ph-1
Ph-2
Ph-5
Ph-6
Reh-1
Rs-2
Sae-1
Se-2
Se-3
Sny-1
Stn-1
Stn-3
Stn-4
Stn-5
Stn-7
Stn-8
Stn-9
Stn-10
Th-1
Th-9
Th-26

Polonium
Agr-1
At-3 through At-8
At-15
Bek-1
Bek-2
Bh-2
Bh-3
Bh-4
Bh-5
Bi-1
Bl-1
Br-3
Br-4
Br-16
Br-18
Br-46

Polonium (*contd.*)
Ca-1
Ca-2
Ca-3
Ca-4
Cat-1
Cm-2
Del-1
Del-2
Dw-2
Fi-1 through Fi-9
Fi-11
Fk-1
Fk-2
Fk-4
Fk-7
Fra-1
Fu-1
Hd-1
Hu-2
Hu-3
Hu-4
Hu-5
Hu-6
Hu-14
Lc-1
Lc-2
Lc-4
Lc-5
Lc-6
Lc-7
Ln-10
Ly-1
Ms-1
Nm-1
Pet-1
Sa-1 through Sa-9
Sa-11 through Sa-17
Se-2
Shi-1
Sm-1
To-5
Wt-1
Yo-1

Potassium
Ai-2
Alb-1
An-4
An-5
An-6
An-8
Beg-7
Beg-8
Bet-1
Bil-1

Potassium (*contd.*)
Bow-2
Br-29
Cg-1
Co-38
Dan-1
Dea-1
Dr-1
Ea-10
Ega-1
Ey-1
Fs-1
Fun-1
Gr-4
Gr-10
Gro-1
Gro-2
Gro-3
Gs-1
Ha-70
Ha-88
Hi-1
Kil-1
Led-1
Ln-13
Ln-17
Ln-18
Lov-1
Lov-2
Ly-1
Mart-1
Mn-5
Mn-7
Mn-8
Nt-1
Oh-1
Pah-1
Pah-2
Pah-4
Rc-1
Rd-2
Rd-3
Rh-1
Rm-1
Ros-3
Ros-4
San-1
Sch-1
Se-2
Sie-1
Sog-1
Spi-2
Spi-3
Stn-8
Stn-9

Potassium (*contd.*)
Sun-3
Tb-1
Ti-2
Ti-3
Ti-4
Ti-5
Ti-6
Ti-7
Tr-7
Tr-8
Tyo-1
Ut-1
Ut-3
Vg-1
Vs-1
Wd-7
Ww-1
Ww-2

Praseodymium
Bl-1
Br-12
Ha-1
Ha-4
Ha-15
Ha-16
Ha-26
Ha-36
Ky-7

Promethium
Ha-1
Ha-26
Ha-31
Ha-32
Ha-34
Ha-36
Ha-38
Ha-58
Ha-66

Protactinium
Co-8
Ha-1
Ha-8
Ha-17
Ha-26
Ha-27
Ha-36
Se-2

Radium
Ac-5
Ac-7
Ac-8
At-13
Au-4
Bh-2

Radium *(contd.)*
Bh-3
Bh-4
Bjh-1
Bjh-2
Bl-1
Bl-5
Bot-1
Br-1
Br-4
Br-6
Br-7
Br-12
Br-14
Br-15
Br-17
Br-18
Br-20
Br-21
Br-27
Br-29
Br-32
Br-35
Br-39
Br-40
Br-42
Br-43
Br-44
Br-54
Bri-1
Bz-1
Cat-1
Co-13
Da-1
Dur-3
Ea-1
Ea-2
Ea-4
Ea-5
Ea-7
Ea-9
Ea-10
Ed-1
Fi-2
Fi-5
Fi-8
Fi-10
Fj-1
Fk-4
Fk-6
Fk-7
Fk-8
Fl-1
Fl-2
Fu-1

Radium *(contd.)*
Ge-1
Ge-2
Gra-1
Ha-32
Ha-76
Ha-77
Ha-103
Hd-1
He-1
Hk-1 through Hk-7
Hs-2
Hu-1
Hu-7 through Hu-12
Hu-14
Hu-16
Hu-17
Hv-1
Hy-6
Iv-1
Ja-4
Ja-6
Kp-6
Kr-1
Kt-3
La-1
Lb-1 through Lb-9
Lb-11
Lb-12
Lb-13
Ln-7
Lr-1
Lr-2
Ly-1
Mae-1
Mae-2
Mah-1
Mi-1
Mn-3
Mn-4
Mn-11
Mn-13
Mr-1 through Mr-9
Mut-1
Mut-2
Mut-3
Mut-4
Mut-5
No-1
No-3
No-6
No-7
No-9
Nu-5
Pal-1

Radium *(contd.)*
Pal-2
Ph-5
Ph-6
Re-2
Reh-1
Rie-1
Rj-2
Ros-1
Ros-2
Ros-3
Ros-4
Rs-1
Sb-1
Se-2
Se-7
Sg-1
Si-1
Sie-1
Sim-1
Sny-1
Spe-1
Spi-2
Spi-3
Spi-5
St-1
St-2
St-3
St-4
Ste-2
Ste-3
Ste-4
Stn-1
Stn-2
Stn-3
Stn-4
Stn-5
Stn-8
Stn-9
Stn-10
Stv-1
Sun-3
Sy-1
Tab-1
To-1
Ut-1
Ut-3
Va-2
Va-5
Va-6
Vd-2
Vd-3
Vd-4
Vd-5
Vd-6

Radon
Beo-1
Bh-2
Bh-4
Bhj-1
Bhj-2
Br-1
Br-10
Br-48
Bw-1
Cl-2
Cn-1
Cor-1
Dw-2
Ea-3
Ea-9
Ea-10
Fu-1
Gla-1
Hk-6
Hod-1
Hod-2
Hon-1
Hu-6
Hu-13
Jc-1
Jk-1
Kp-6
Kus-1
La-1
Lb-2
Lb-9
Lc-3
Lr-2
Lr-3
Lr-4
Ly-1
McK-1
Mf-1
Mk-1
Mk-2
Mn-4
Mys-1
Pin-1
Re-1
Rj-2
Ros-1
Ros-2
Ros-4
Rus-1
Sco-1
Scr-1
Scr-2
Sf-1
Sf-2

Radon (*contd.*)
Sie-1
Ste-1
Stn-3
Stn-5
Vd-2
Vd-4
Vd-5
Vd-6

Radon—thoron
Ae-1
Bw-1
Cl-2
Ea-9
Ea-10
Kr-2
Ly-1
Mys-1
Mys-3
Stn-3

Rhenium
Bu-1
Ha-87
Ha-89
Ha-101
She-1
She-2

Rhodium
Ha-22
Ha-85
Ha-89
Ha-101

Rubidium
Beg-6
Beg-7
Beg-8
Dea-1
Ew-2
Gi-1
Ha-21
Kil-1
Ln-13
Ln-18
Lov-1
Lov-2
Mart-1
Pah-4
Rh-1
Rm-2
Sti-1
Sti-3
Sz-1
Ti-4
Ti-5
Ti-6

Rubidium (*contd.*)
Tr-3
Tr-7
Tr-8
Tyo-1
Zi-1
Zi-2
Zi-3

Ruthenium
Ab-6
Bn-10
Bn-11
Bn-13
Bn-14
Br-7
Br-50
Cat-1
Fk-4
Ha-1
Ha-4
Ha-9
Ha-10
Ha-26
Ha-51
Ha-89
Ha-101
Hd-1
Hy-3
Hy-4
Hy-5
Ja-5
Kt-2
Kt-3
Kt-10
Kt-11
Kt-12
Mos-2
Mos-4
Ph-4
Sts-1
Th-15
Th-16
Th-17
Th-20
Th-23
Th-25
Th-27
Wid-1

Samarium
Ha-18
Ha-22
Ha-33
Ha-36
Ha-50

Scandium
Ha-83
Ha-84
Ha-88
Lx-1

Selenium
Du-14
Du-16
Ew-2
Fz-1
Ha-15
Ha-22
Hei-1
Hol-1
Kh-8
Kh-9
Led-1
Mkp-1
Mkp-2
Mkp-3
Mx-1
Mx-2
Mx-3
Mx-4
Mx-5
Pa-2
Rf-1
Rf-2
Rt-1
Sm-2
Sm-3
Sm-4
Str-1
Un-1

Silicon
Alb-1
Bow-2
Fw-1
Gol-1
Gw-1
Hol-1
Hol-2
Kg-1
Kg-2
Kg-3
Kg-4
Kg-5
Kus-1
McC-1
McN-1
Rc-1
Rg-2
San-1
Tie-1
Un-1

Silver
Alb-1
Bg-5
Bg-6
Ck-4
Ck-7
Ew-2
Gol-1
Ha-19
Ha-81
Kh-4
Kh-7
Kh-8
Kh-9
Kn-1
Rm-2
Rt-1
San-1
Sha-1
So-1
Sti-1
Sti-3
Sun-3
Sz-1
Ti-1 through Ti-7
Tie-1

Sodium
Alb-1
Bau-4
Bau-6
Bau-7
Bau-9
Beg-7
Beg-8
Bet-1
Bh-6
Bil-1
Bl-1
Bos-1
Bos-2
Bos-4
Bow-2
Br-18
Bw-2
Cd-1
Co-38
Dob-1
Dr-1
Em-1
Em-2
Fin-1
Fs-1
Fs-4
Gr-14
Gro-1

Sodium (*contd.*)
Gro-2
Gro-3
Ha-28
Ha-69
Ha-70
Ha-72
Ha-88
Hd-1
Ho-13
Ho-15
Kel-1
Kra-1
Kra-2
Ky-7
La-2
Led-1
Ln-13
Ln-18
Lo-1
Mn-5
Oh-1
Op-1
Ph-4
Rc-1
Rh-1
Rm-1
San-1
Sch-1
Sn-5
Sog-1
Sun-3
Tb-1
Tis-1
Tr-1
Tr-8
Ut-1
Vu-1
Wd-7

Strontium
Ab-4
Ac-4
Ac-8
And-1
At-11
At-12
Aw-1
Aw-2
Aw-3
Bau-12
Bau-16
Bh-2
Bl-1
Br-1
Br-5

Strontium (*contd.*)
Br-6
Br-7
Br-12
Br-14
Br-15
Br-20
Br-21
Br-22
Br-25
Br-29
Br-32
Br-36
Br-43
Br-45
Br-46
Br-47
Br-49
Br-50
Br-53
Br-54
Bri-1
Bry-1
Buy-1
Cas-1
Cat-1
Cat-2
Cat-3
Cd-1
Cd-2
Cd-3
Che-1
Cl-3
Cl-4
Cl-5
Cl-6
Cl-7
Cl-8
Cl-9
Cn-2
Cn-4
Co-7
Co-13
Co-16
Co-17
Co-18
Co-24
Co-25
Co-28
Co-29
Co-31
Co-32
Co-34
Co-35
Co-36

Strontium (*contd.*)
Co-37
Co-39
Co-40
Co-41
Com-1
Com-2
Cr-2
Do-2
Dur-3
Ea-10
Ed-2
Eg-1
Eg-2
Eg-3
Ei-1
Ei-2
Ei-3
Ei-4
Ei-5
En-2
En-4
En-5
Fk-4
Fk-5
Fk-6
Fk-9
Fk-10
Fk-11
Fk-12
Fr-1
Fr-2
Fr-3
Fr-6
Fr-8
Fra-1
Fs-5
Fu-1
Go-1
Go-2
Gol-1
Gr-13
Gr-18
Gra-1
Ha-1
Ha-4
Ha-5
Ha-15
Ha-16
Ha-20
Ha-21
Ha-26
Ha-34
Ha-35
Ha-38

Strontium (*contd.*)
Ha-49
Ha-50
Ha-51
Ha-58
Ha-64
Ha-66
Ha-75
Ha-77
Ha-78
Ha-80
Ha-81
Har-1
Har-2
Har-4
Har-5
Har-6
Hd-1
Hiy-1 through Hiy-7
Hr-2
Hs-3
Hy-5
Hy-6
Ja-1
Jn-1
Jy-1
Jy-3
Kap-1
Kas-1
Kh-9
Kha-1
Kik-3
Kik-4
Kp-1
Kp-2
Kp-3
Kp-4
Kp-5
Kp-7
Krm-1
Kt-10
Kt-11
Kt-12
Ku-1
Kv-1
Kz-1
La-1
La-2
Lei-1
Lew-1
Lib-1 through Lib-7
Ln-10
Ln-12
Ln-14
Ln-15

Strontium (*contd.*)
Ln-17
Ln-19
Lou-1
Lp-2
Ls-5
Ls-7
Ls-8
Ls-9
Ls-11
Ls-12
Ls-13
Ls-14
Lt-1
Lt-3
Mar-1
Mar-2
Mav-1
Md-1
Md-2
Md-4
Md-5
Md-7 through Md-16
Mei-1
Mn-5
Mn-12
Mos-2
Mos-3
Mos-4
Mw-2
Mys-2
No-1
No-6
No-9
Nw-1
Om-1
Om-2
Om-3
Pc-1
Pe-1
Pe-2
Pet-1
Pig-1
Ray-1
Ray-2
Ray-3
Rc-1
Rg-1
Rl-1
Rm-1
Rm-2
Ros-1
Rs-2
Se-2
Se-6

Strontium (*contd.*)
Shi-1
Sho-1
Sny-1
Sti-1
Sti-2
Sti-3
Sti-4
Stn-3
Stn-4
Stn-5
Stn-6
Stn-8
Stn-9
Su-1
Su-2
Sz-1
Th-24
Th-28
Ti-1 through Ti-7
Tm-2 through Tm-8
Tm-10
Tm-11
Un-1
Ut-1
Ut-2
Ut-3
Va-1
Va-2
Va-3
Va-4
Va-6
Va-7
Va-8
Vc-5
Ve-3
War-1
War-2
War-3
Wd-5
Wn-1
Wr-5

Sulfur
Amp-2
Amp-3
Bau-11
Bea-2
Bea-3
Bea-4
Boa-1
Bor-1
Bor-2
Bos-1
Bos-2
Bos-3

Sulfur (*contd.*)
Bos-4
Bos-5
Co-13
Co-30
Co-38
Dd-1 through Dd-10
Dek-1
En-1
En-3
Ger-1
Gg-1
Gra-1
Gt-1
Jy-3
Jy-5
Kas-1
Kre-1
Kul-1
Kul-2
La-1
La-2
Lev-1
Lj-1
Maa-1
Mac-1
Mac-2
Mh-1
Mn-2
Mon-1
Nh-1
Ny-1
Nz-1
Nz-2
Ol-1
Pah-3
Se-2
Sh-1
Sun-3
Ta-1
Ta-2
Ta-3
Ta-4
Tb-1
Tb-2
Ut-2
Va-4
Wj-1

Tantalum
Cr-1
Cr-2
Do-2
Do-3
Ha-38
Ha-50

Tantalum (*contd.*)
Ha-83
Ha-87
Ha-88
Ha-101
Rt-1
Su-1
Su-2
Su-3

Technetium
Ha-19
Ha-21
Ha-101

Tellurium
De-1
De-2
Ha-1
Ha-4
Ha-9
Ha-10
Ha-26
Har-3
Ja-2
Led-1
Lv-1
Mx-3
Ros-1
Rt-1

Terbium
Dur-3
Ha-31
Ha-34
Ha-36
Ha-63
Ha-79
Ha-83
Ha-89
Ky-8

Thallium
Bc-1
Cox-1
Dur-1
Ha-34
Ha-84
Ha-101
Kh-9
Ld-1
Ld-2
Rg-2
Rt-1
Shw-1
Te-1
Tru-1

Thorium
Ac-7

Thorium (*contd.*)
Ah-1
Am-1
At-13
Bh-1
Bh-4
Bh-6
Bl-1
Boe-1
Br-49
Br-54
Brg-1
Dw-2
Erl-1
Et-1
Fk-4
Fk-7
Fr-2
Fra-1
Fu-1
Gb-1
Ge-2
Ha-1
Ha-8
Ha-26
Ha-27
Ha-29
Ho-4
Hu-7
Hu-14
Hu-15
Hy-2
Ja-3
Lb-2
Lb-6
Lb-7
Lb-10
Mae-1
Mae-2
Mau-1
Mau-2
Mau-3
Mi-1
Mik-1
Mn-9
Mn-11
Mt-1
Mt-2
Mys-3
Or-1
Pr-1
Rd-1
Reh-1
Rj-1
Rj-2

Thorium (*contd.*)
Ros-1
Ros-2
Ros-4
Rs-2
Sco-2
Sco-3
Se-2
Se-4
Se-6
Sl-1
Ste-2
Stn-3
Stn-4
Stn-5
Stn-8
Stn-9
Stn-10
To-3
Vd-1
Wit-1

Thulium
Ha-32
Ha-36
Ha-50
Ha-84
Ha-88
Jy-6
Ky-7
Ky-8
Ros-1

Tin
Alb-1
Brd-2
Ck-4
Ck-7
Dt-1
Ew-2
Ha-18
Ha-19
Ha-20
Ha-101
Kc-1
Kh-4
Kh-9
Kn-2
Sei-1
Sha-1
Sun-3
Sv-1
Sz-1
Ti-1 through Ti-7
Tie-1

Titanium
Bar-1

Titanium (*contd.*)
Beg-4
Beg-5
Bli-1
Brg-1
Cv-1
Ew-2
Gol-1
Kc-1
Kh-9
Kk-1
Kk-2
Mai-1
Mai-2
Mai-3
Mai-4
Mai-5
Rc-1
San-1
Sha-1
Sti-1
Sti-3
Ti-1 through Ti-7

Uranium
Ac-1
Ber-1
Ber-2
Ber-3
Ber-4
Ber-5
Bh-4
Bh-6
Br-5
Br-15
Br-18
Br-40
Br-44
Dal-1
Dw-2
Er-1
Fk-4
Fk-6
Fk-7
Fu-1
Ha-1
Ha-3
Ha-16
Ha-17
Ha-19
Ha-92
Hd-1
Hf-1 through Hf-9
Ho-2
Ho-3
Ho-7

Uranium (*contd.*)
Ho-8
Ho-9
Ho-10
Ho-14
Hv-1
La-2
Ly-1
McL-1
Ni-2
No-5
No-8
Nu-1
Nu-2
Nu-3
Nu-6
Nu-8
Nu-10
Pet-1
Rt-1
Sae-1
Se-2
Sny-1
Sto-1
Sto-2
Sx-1
Tn-1
Tn-2
Tn-3
Vo-1

Vanadium
Di-1
Di-2
Ha-16
Ha-95
Ht-3
Kc-1
Kh-9
Kn-1
Ml-2
Mx-3
Rg-2
Rt-1
San-1
Sha-1
Ti-1 through Ti-7
Tl-1
Un-1

Wolfram
Ha-84
Ha-101
Kin-1
Kin-2
Kin-3

Wolfram (*Contd.*)
Ws-1
Ws-2

Xenon
Fea-1
Fea-2
Ha-1
Ha-4
Ha-9
Ha-10
Ha-26
Ha-51
Hd-1
La-6

Ytterbium
Ha-33
Ha-36
Ha-86

Yttrium
Ab-4
Ac-4
At-9
Bl-1
Br-1
Br-6
Br-12
Br-20
Br-21
Br-28
Br-29
Bul-1
Co-8
Co-17
Co-18
Co-34
Cr-1
Do-1
Do-2
Do-3
Du-17
Du-18
Fk-4
Fr-7
Fra-1
Fu-1
Gra-1
Ha-1
Ha-4
Ha-5
Ha-7
Ha-9
Ha-10
Ha-14
Ha-15
Ha-18

Yttrium (*contd.*)
Ha-19
Ha-21
Ha-22
Ha-26
Ha-40
Ha-50
Ha-51
Ha-64
Ha-86
Hd-1
Hy-4
Jy-2
Jy-3
Jy-6
Kt-12
Ky-4
Ky-5
Ky-6
Ky-7
Ky-8
Li-2
Ls-2
Ls-4
Ls-7
Lt-2
Lt-3
Lx-1
Md-17
Rs-2
Se-2
Se-3
Spo-1
Su-1
Su-2
Su-3
Su-4
Tm-1
Tm-2
Tm-8
Tm-9
Va-2
Va-8

Zinc
Alb-1
Ban-1
Be-1
Bee-1
Bg-1
Bg-2
Bg-3
Bg-5
Bg-6
Bir-1
Br-54
Brg-1
Ck-8
Co-3
Co-10
Co-13
Co-17
Co-18
Co-20
Co-38
Ct-2
Cu-1
Dk-1
Dri-1
Ej-2
Ev-1
Ew-1
Ew-2
Fe-1
Fe-2
Gol-1
Gu-1
Gu-2
Gu-3
Ha-21
He-1
Hea-1
Hy-4
Hy-9
Kas-1
Kc-1
Kc-2
Kh-8
Kh-9
Kor-1
Kt-12
Low-1
Lu-1
McI-1
Mw-1
Mw-3
Mw-4
Mw-5
Mw-6
Rc-1
Rg-1
Rie-1
Ros-4
Rt-1
Rw-1
Sad-1
Sct-1
Sh-1
Sha-1
Sn-1
Sn-2
Sn-4
Sz-1
Ti-1 through Ti-7
Tie-1
Tu-1
Tup-1
Ty-2
Un-1
Ut-2
Ve-1
Ve-2
Ve-4
Wd-3
Wd-7

Zirconium
Ab-4
Bl-1
Cr-1
Cr-2
Cra-1
Dk-1
Do-1
Do-2
Ha-1
Ha-4
Ha-7
Ha-9
Ha-15
Ha-16
Ha-19
Ha-20
Ha-21
Ha-22
Ha-26
Ha-50
Ha-51
Hd-1
Kor-1
Led-1
Mea-1
Rt-1
Sco-4
Se-2
Se-4
Su-2
Ut-1

Fission products
Bl-1
Co-8
Co-17
Co-18
Ha-28

Fission products (*contd.*)
Hy-4
Hy-5
Ja-5
Ln-10
Ly-1
Lz-1
Mw-2
Pet-1
Rs-2
Ut-2
Ut-3

General
Ag-1
Ag-2
Ba-1
Be-1
Br-22
Br-31
Br-51
Ch-1
Co-21
Cp-1
Ev-1

General (*contd.*)
Fa-1
Gd-1
Hw-1
Hy-1
Jb-1
Mow-1
Ni-3
Nu-4
Pt-1
Wg-1

END OF VOL.